GRUMMAN

SPACE FABRICATION DEMONSTRATION SYSTEM

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

PHASE I & II FINAL REPORT

NASA-MSFC Contract NAS8-32472

NSS-SFDS-RP015

November 30, 1979

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK 11714

NSS-SFDS-LR126
Contract NAS8-32472
November 30, 1979

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Attention: Erich E. Engler, COR
Code EP-13, Bldg. 4610

Subject: SPACE FABRICATION DEMONSTRATION SYSTEM -
Composite Beam Cap Fabricator Development
Phase I and II Final Report Presentation

Enclosures: (1) Subject, Executive Summary, Presented to NASA-MSFC October 24, 1979
(2) Subject, Presented to NASA-MSFC October 24, 1979

SUMMARY

On October 24, 1979 Grumman and Goldsworthy Engineering Incorporated presented the results of their combined Phase I & II composite beam cap fabricator pultrusion process development efforts. The sum and substance of the effort included the following:

- Pultrusion is a workable, though difficult, process for thermoset and thermoplastic graphite composite closed caps
- Continuous material shaping preparatory to entering the pultrusion die is still to be demonstrated.

DISCUSSION

Two final report presentations were made at NASA-MSFC on October 24, 1979. The first, in the morning, consisted of a complete review of all of the effort conducted toward demonstrating that the pultrusion process was a viable approach to producing a composite beam cap fabricator which would fit within the present aluminum cap forming portion of the aluminum beam builder. The second, in the early afternoon, was an executive summary of the first.

Composite Beam Cap Fabricator Executive Summary

Enclosure (1) is a reprint of the material viewed and discussed as the final review executive summary. It follows the following format in abbreviated form. At this meeting the comments were made that we would be ready to proceed with the detail design, fabrication and test of a composite beam cap fabricator and ribbon forming machine following a demonstration of the continuous material shaping section of the concept drawing shown on page 15.

Composite Beam Cap Fabricator Review

Enclosure (2) is a reprint of the material which was viewed during the final review presentation. The following reminders are given to those who were present at the meeting and to serve as a note to others reviewing this material:

- o Introduction and programmatic remarks - pages 1-6
- o Process development phase I and II tasks - pages 7-8
- o Closed cap thermoset effort - pages 9-14
- o Closed cap thermoplastic effort - pages 15-27
- o Material and cap properties - pages 28-30
- o Ribbon and cap fabricator configurations - pages 31-48
- o Summary including 2 bay thermoset beam - pages 49-51

CONCLUSION

While the above demonstrated major portions of the pultrusion process technology associated with various machine sections of a closed composite beam cap fabricator some unanswered questions remained, i.e.:

- o Can the thermoplastic ribbon stock be shaped prior to entering the pultrusion die in the machine length shown?
- o When might three (3) 11 ft. and one (1) 6 ft closed thermoplastic beam caps be produced?

RECOMMENDATION

NASA-MSFC review the material presented as our final report for this contracted effort and advise us as to what their conclusion and recommendation for the next step might be.

Should you have any question, comment or suggestions with regard to the above, the enclosures or the SFDS program in general, please advise us.

Very truly yours,

GRUMMAN AEROSPACE CORPORATION

Walter K. Muench
SFDS Program Manager

WKM/dr

cc: Distribution: NASA-MSFC
Grumman
Goldsworthy

ENCLOSURE (1)

SPACE FABRICATION DEMONSTRATION SYSTEM

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

PHASE I & II FINAL REPORT

EXECUTIVE SUMMARY

Goldsworthy

GRUMMAN

SPACE FABRICATION DEMONSTRATION SYSTEM

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

PHASE I & II FINAL REPORT
EXECUTIVE SUMMARY

PRESENTED TO
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
OCTOBER 24, 1979

Goldsworthy

GRUMMAN

1618-2018

INTRODUCTION

COMPOSITE BEAM CAP FABRICATOR

- NASA/MSFC CONTRACT NAS 8-32472
  - CONTRACTING OFFICER REPRESENTATIVE — ERICH E. ENGLER
- PRIME CONTRACTOR — GRUMMAN AEROSPACE CORPORATION
  - PROGRAM MANAGER — WALTER K. MUENCH
- SUBCONTRACTOR — GOLDSWORTHY ENGINEERING INCORPORATED
  - PROGRAM MANAGER — GLENN W. EWALD

COMPOSITE BEAM CAP FABRICATOR

PROGRAM OBJECTIVES

- TO DEVELOP AND DEMONSTRATE THE FEASIBILITY OF AUTOMATICALLY PRODUCING COMPOSITE BEAM CAPS
- COMPOSITE BEAM CAP FABRICATOR TO BE COMPATIBLE WITH THE CURRENT ALUMINUM BEAM BUILDER
- USE EXISTING DEVELOPMENT FACILITIES, TOOLING AND EQUIPMENT
- COMPOSITE MATERIAL TO PROVIDE DIMENSIONAL STABILITY, WEIGHT & STRENGTH EQUAL TO OR BETTER THAN ITS ALUMINUM COUNTERPART

COMPOSITE BEAM CAP FABRICATOR

TASKS

MSFC/GRUMMAN/GOLDSWORTHY
7/18/79 MEETING
DECISIONS

- PHASE I
  - PROCESS DEVELOPMENT
    - THERMOSET & THERMOPLASTIC MATERIALS — DROP THERMOSET
    - OPEN & CLOSED CAPS — DROP OPEN CAPS
  - DEVELOPMENT MATERIAL & CAP SELECTION
  - DELIVER 30m OF SELECTED BEAM CAP (5-6 m LENGTHS)
- PHASE II
  - COMPOSITE BEAM CAP FABRICATOR PRELIMINARY DESIGN
  - BEAM CAP/CROSS BRACE FASTENING TECHNIQUE IDENTIFICATION
  - BEAM CUT-OFF METHOD

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

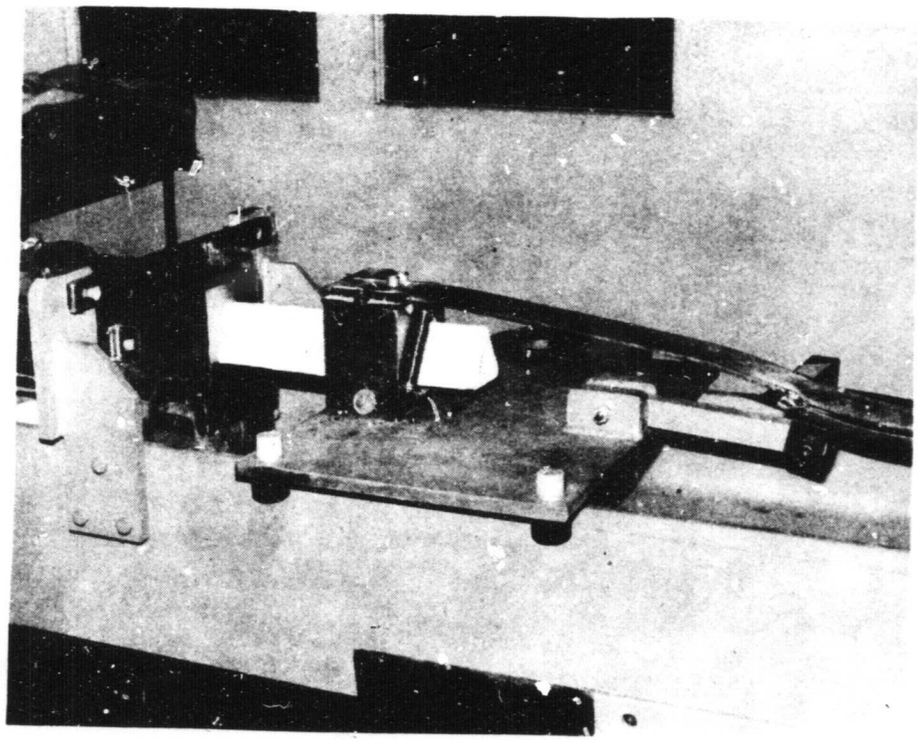

Figure 1

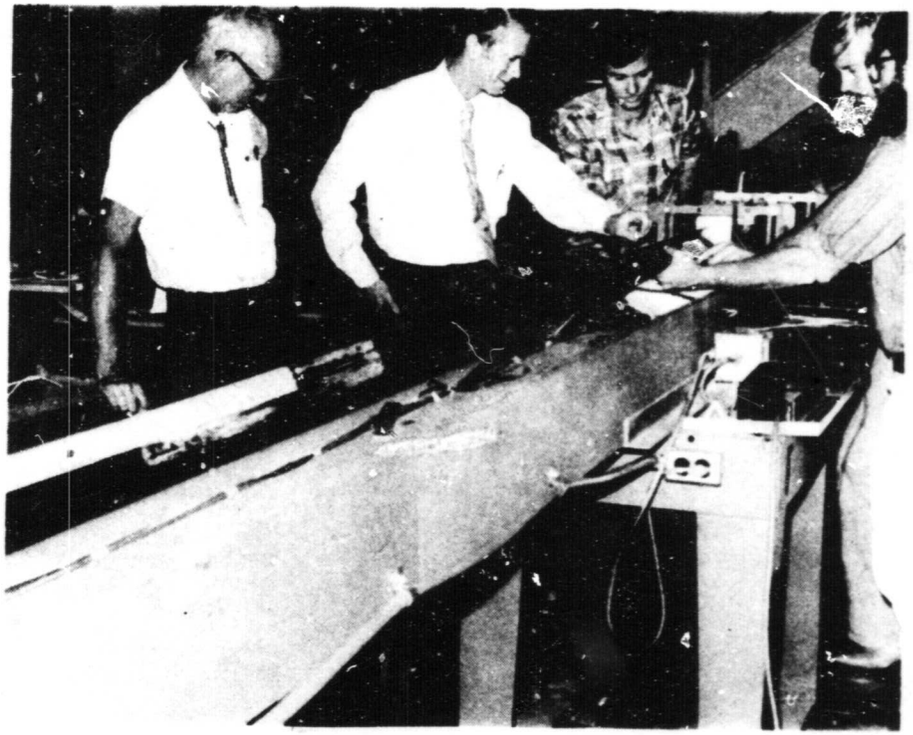

Figure 2

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

Figure 3

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

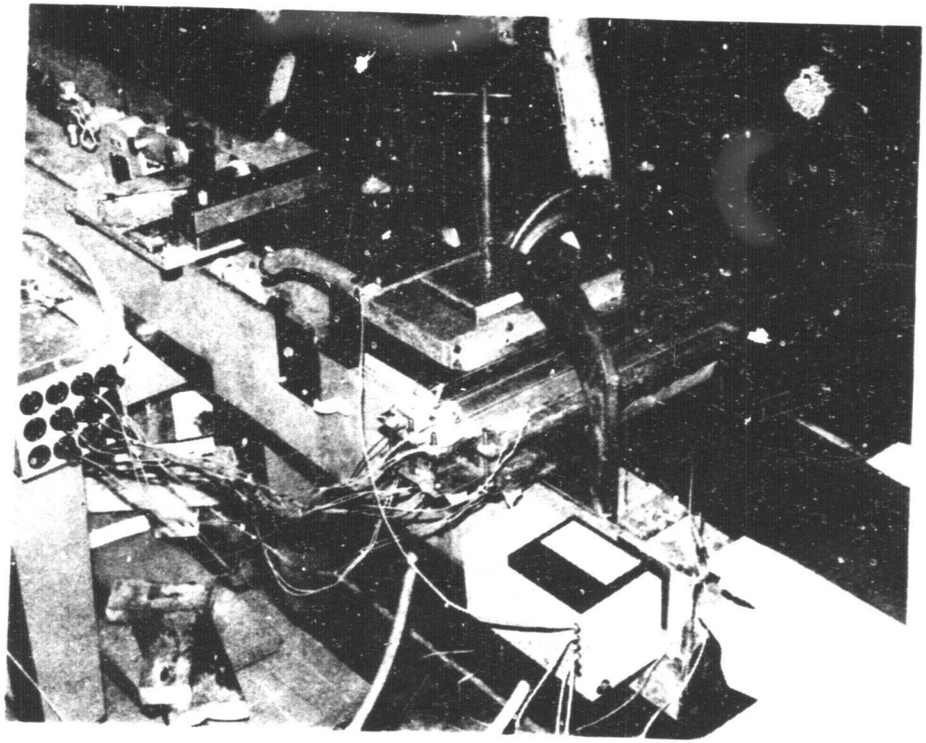

Figure 4

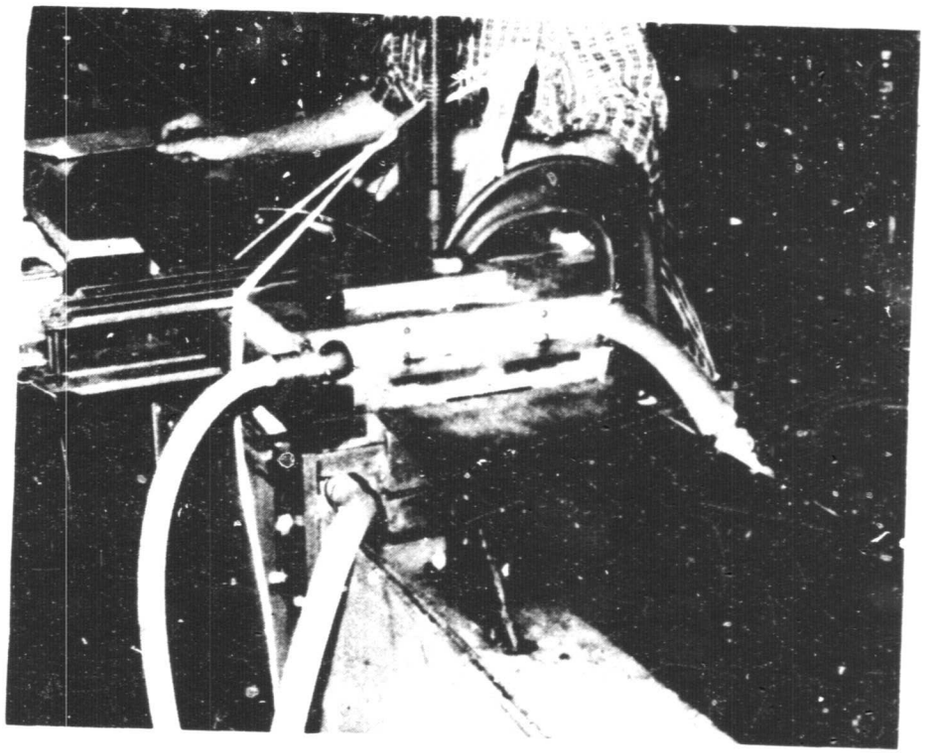

Figure 5

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

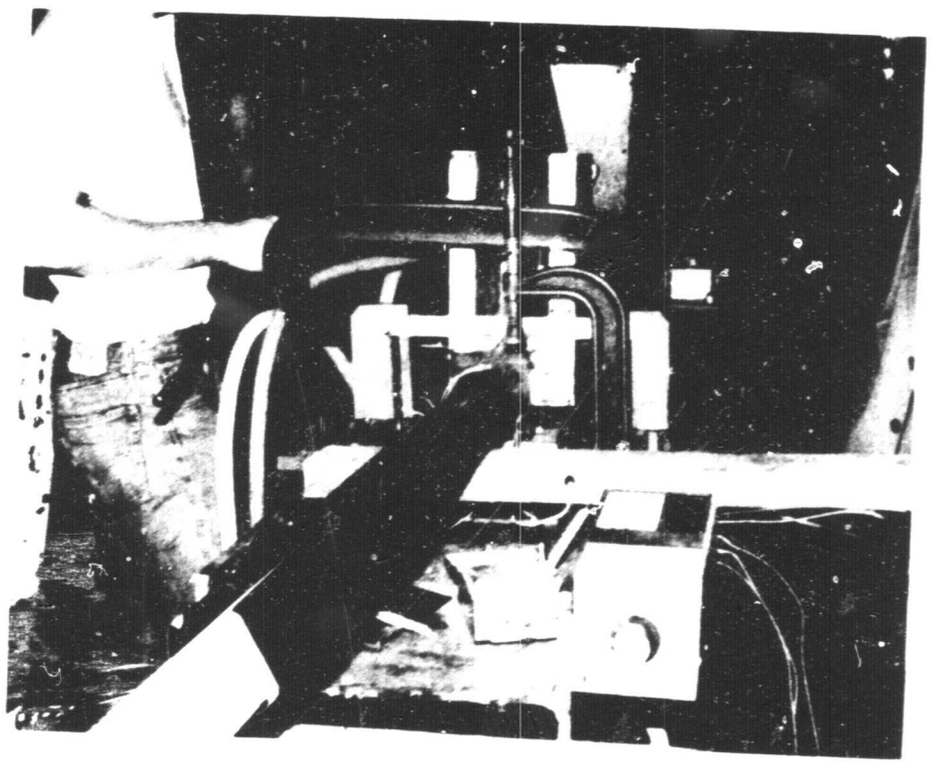

Figure 6

PROCESS EVALUATION

GRUMMAN LABORATORY DATA

BEAM CAP PROPERTIES

MATERIAL TYPE IDENTITY LAY-UP	COMPOSITE THERMOSET GR/PE 0°-0°±45°M-0°-0°	COMPOSITE THERMOPLASTIC GR/PS 0°-0°±45°-0°-0°	METAL ALUMINUM 2024-T3
TYPE OF CAP			
THICKNESS, IN. WEIGHT, LBS/FT DESIGN ULTIMATE LOAD, LBS FAILURE LOAD, LBS	0.038 0.17 — 720*	0.035 0.17 — ?	0.016 0.12 433 505*
TENSILE STRENGTH LONG, KSI TENSILE MODULUS LONG, MSI FLEXURE STRENGTH LONG, KSI FLEXURE MODULUS LONG, MSI	111.5 12.8 231.8 14.9	— — 176.0 16.0	47 10.5 NA NA
FLEXURE STRENGTH TRANS, KSI FLEXURE MODULUS TRANS, MSI	8.1 **	13.7 0.5	NA NA

*SPECIMEN LENGTH = 59.05 IN
**MODULUS TOO LOW TO MEASURE

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1618-129B

COMPOSITE BEAM CAP FABRICATOR

CONFIGURATION

- COMPOSITE RIBBON FABRICATOR
- COMPOSITE BEAM CAP FABRICATOR
  - DEMONSTRATION MACHINE
  - ALUMINUM BEAM BUILDER INSTALLATION

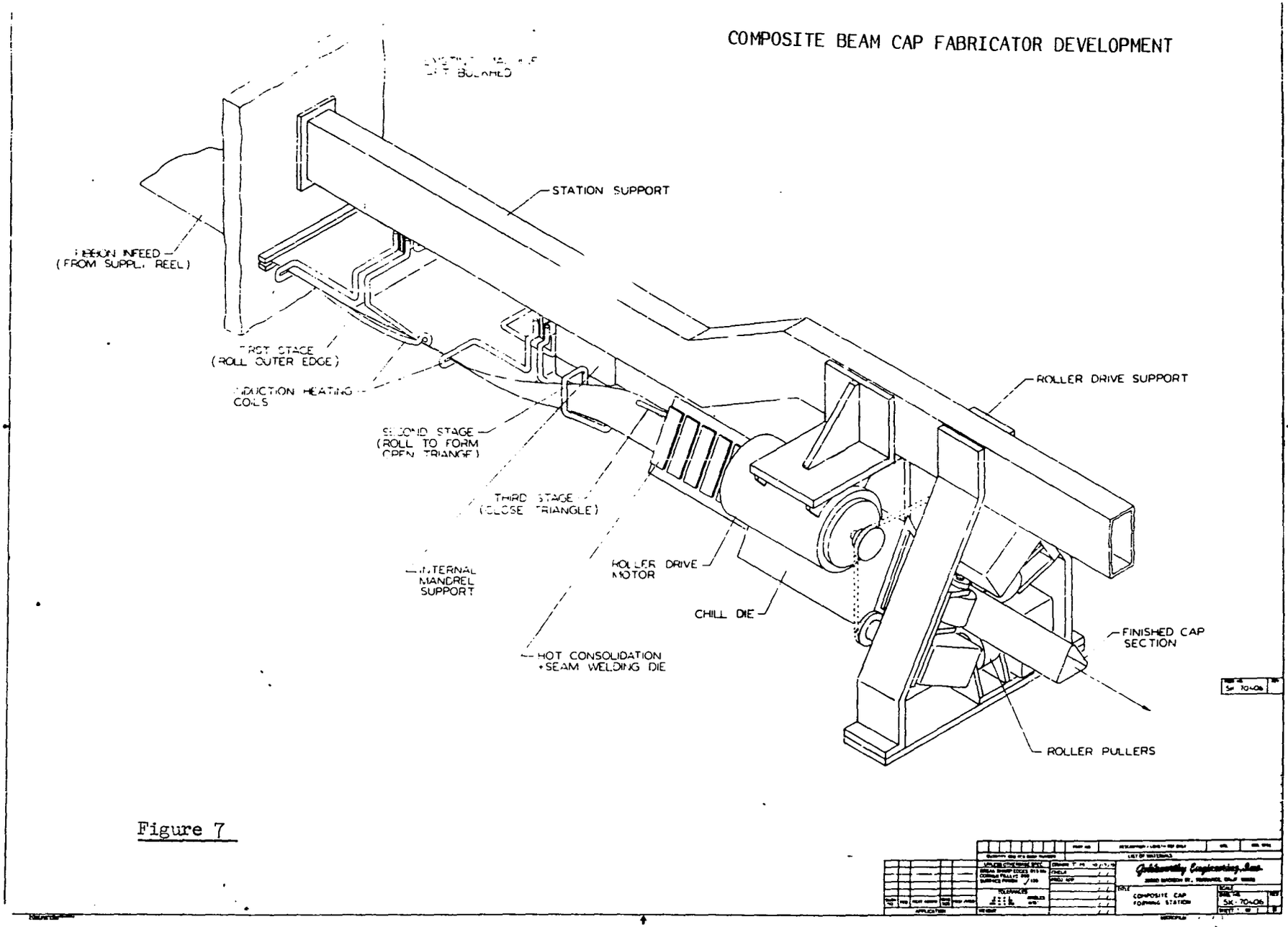

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT
STATION SUPPORT
FIBERGLASS INFEED
(FROM SUPPL. REEL)
FIRST STAGE
(ROLL OUTER EDGE)
INDUCTION HEATING
COILS
SECOND STAGE
(ROLL TO FORM
OPEN TRIANGLE)
THIRD STAGE
(CLOSE TRIANGLE)
INTERNAL
MANDREL
SUPPORT
ROLLER DRIVE
MOTOR
CHILL DIE
HOT CONSOLIDATION
+SEAM WELDING DIE
ROLLER DRIVE SUPPORT
FINISHED CAP
SECTION
ROLLER PULLERS
SK-70-06
COMPOSITE CAP
FORMING STATION

Figure 7

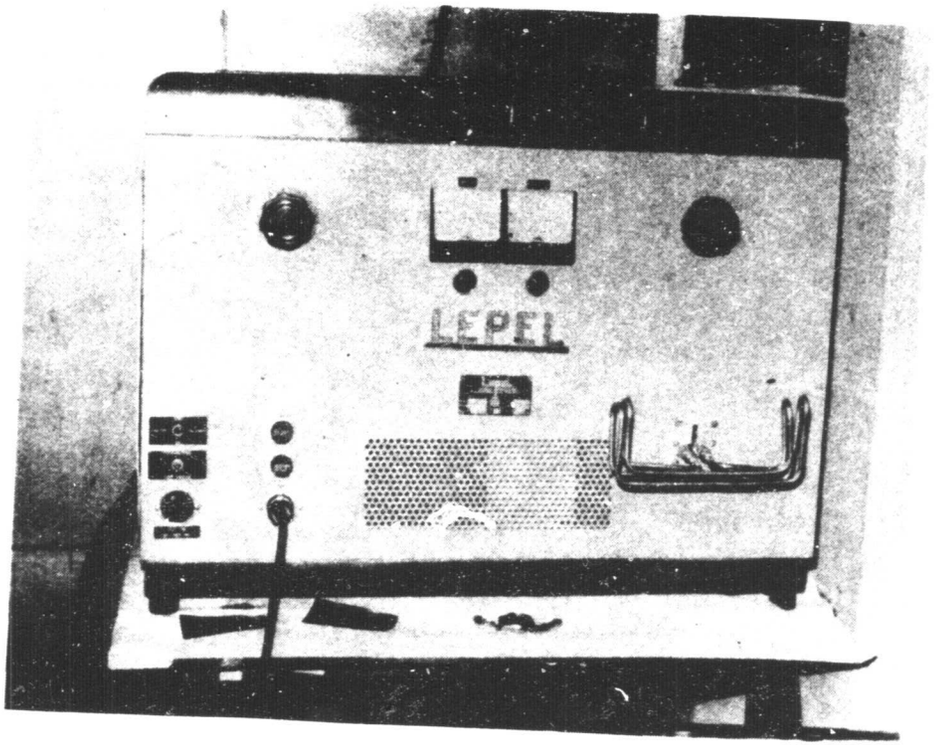


Figure 8

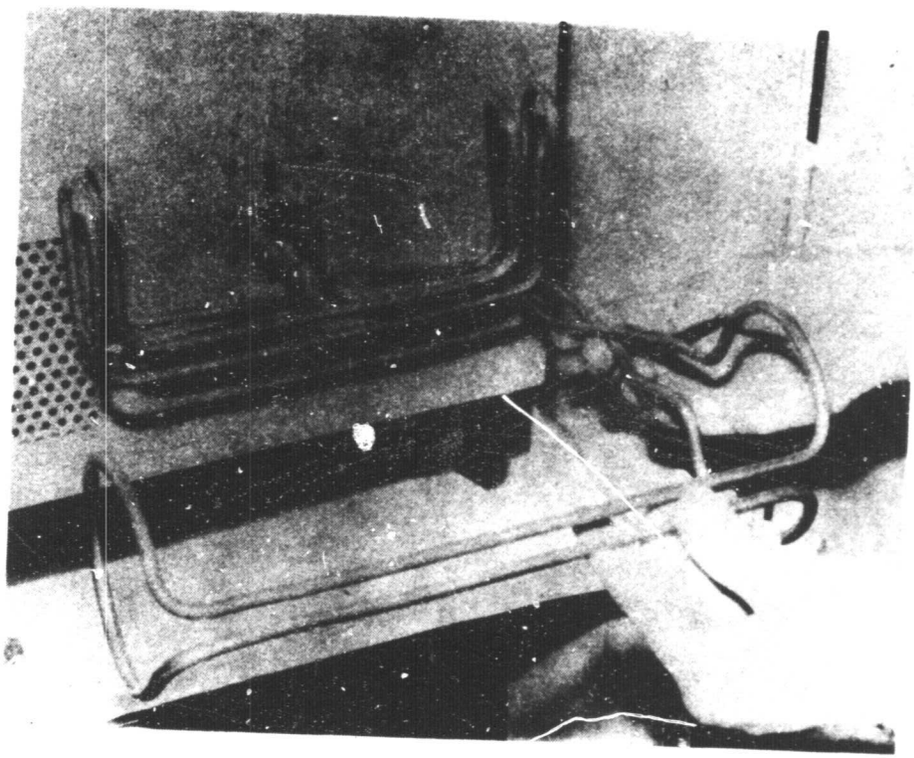


Figure 9

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

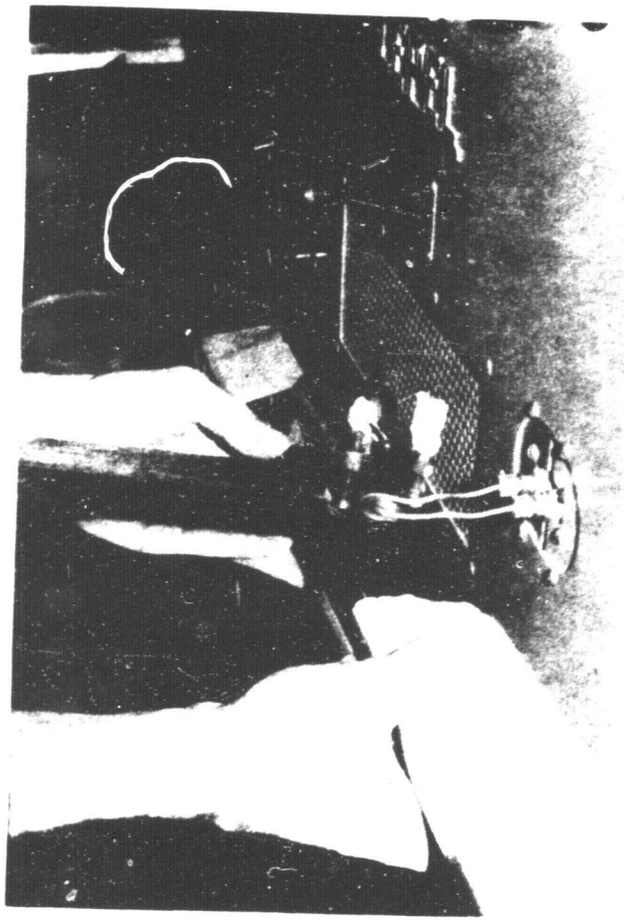


Figure 10

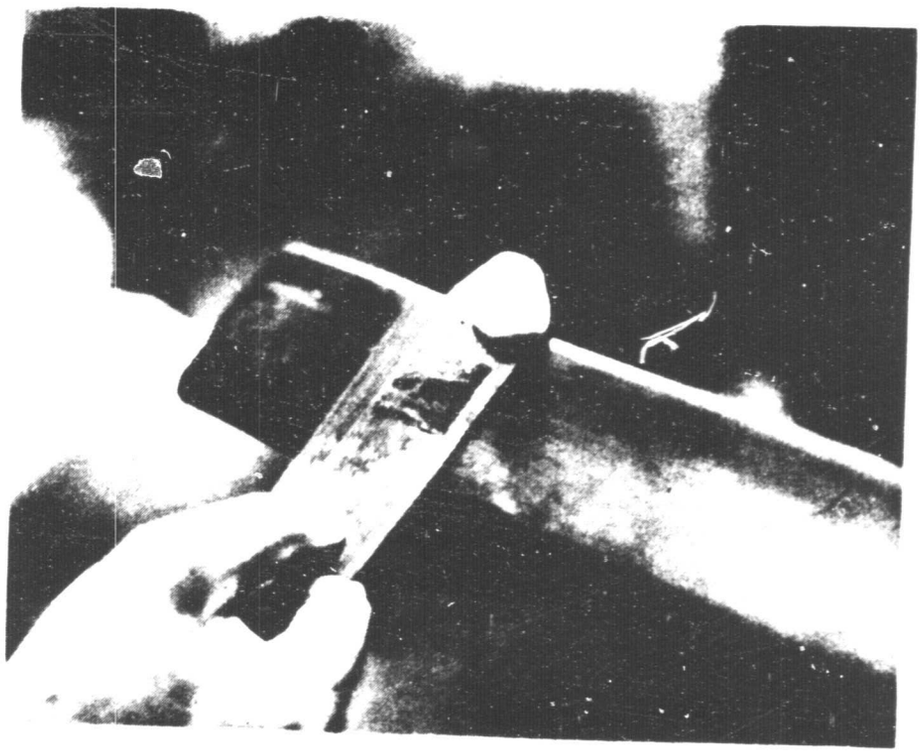


Figure 11

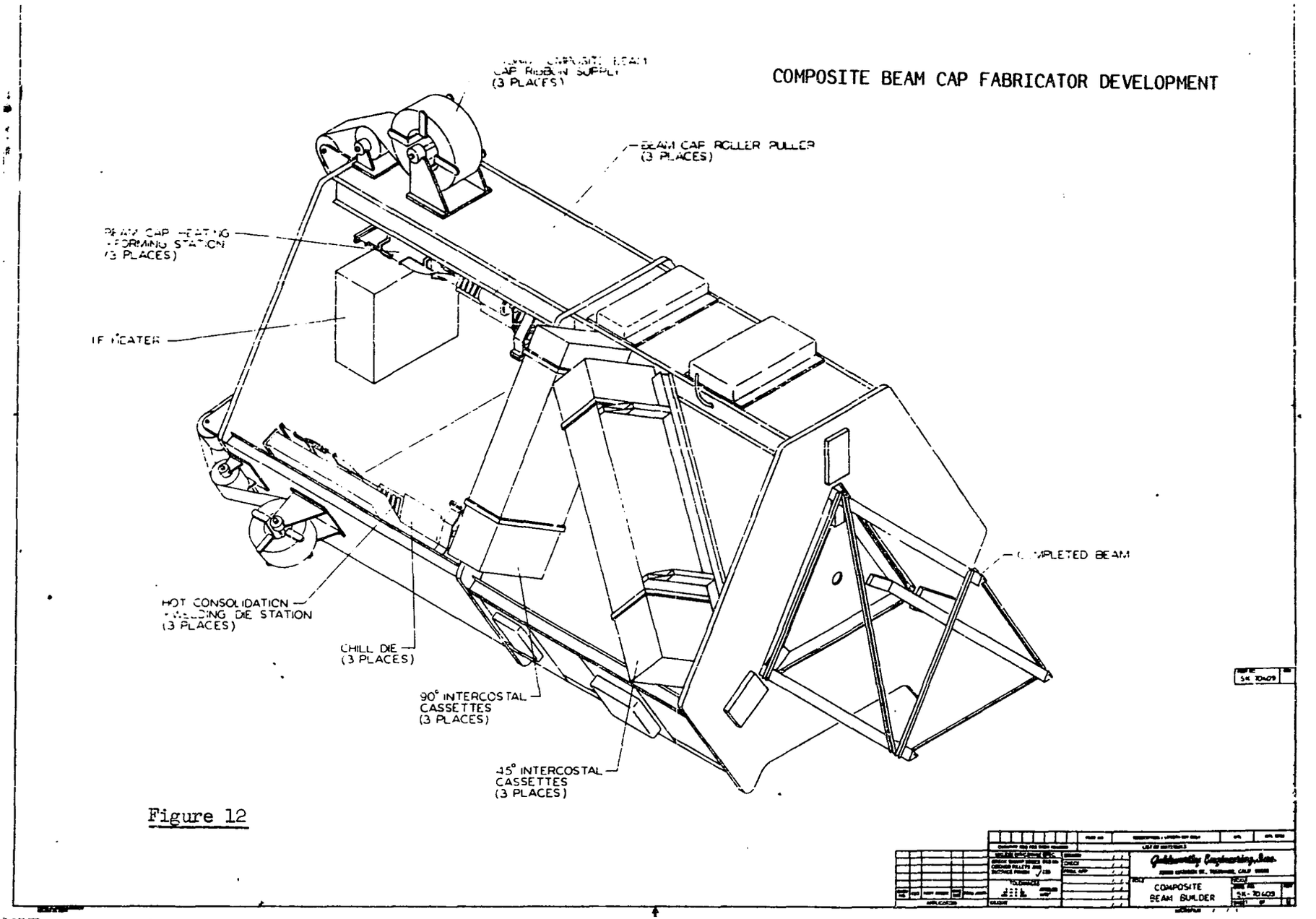

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT
(3 PLACES)
BEAM CAP ROLLER PULLER
(3 PLACES)
(3 PLACES)
IF HEATER
HOT CONSOLIDATION
(3 PLACES)
CHILL DIE
(3 PLACES)
90° INTERCOSTAL
CASSETTES
(3 PLACES)
45° INTERCOSTAL
CASSETTES
(3 PLACES)
COMPOSITE
BEAM BUILDER

Figure 12

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

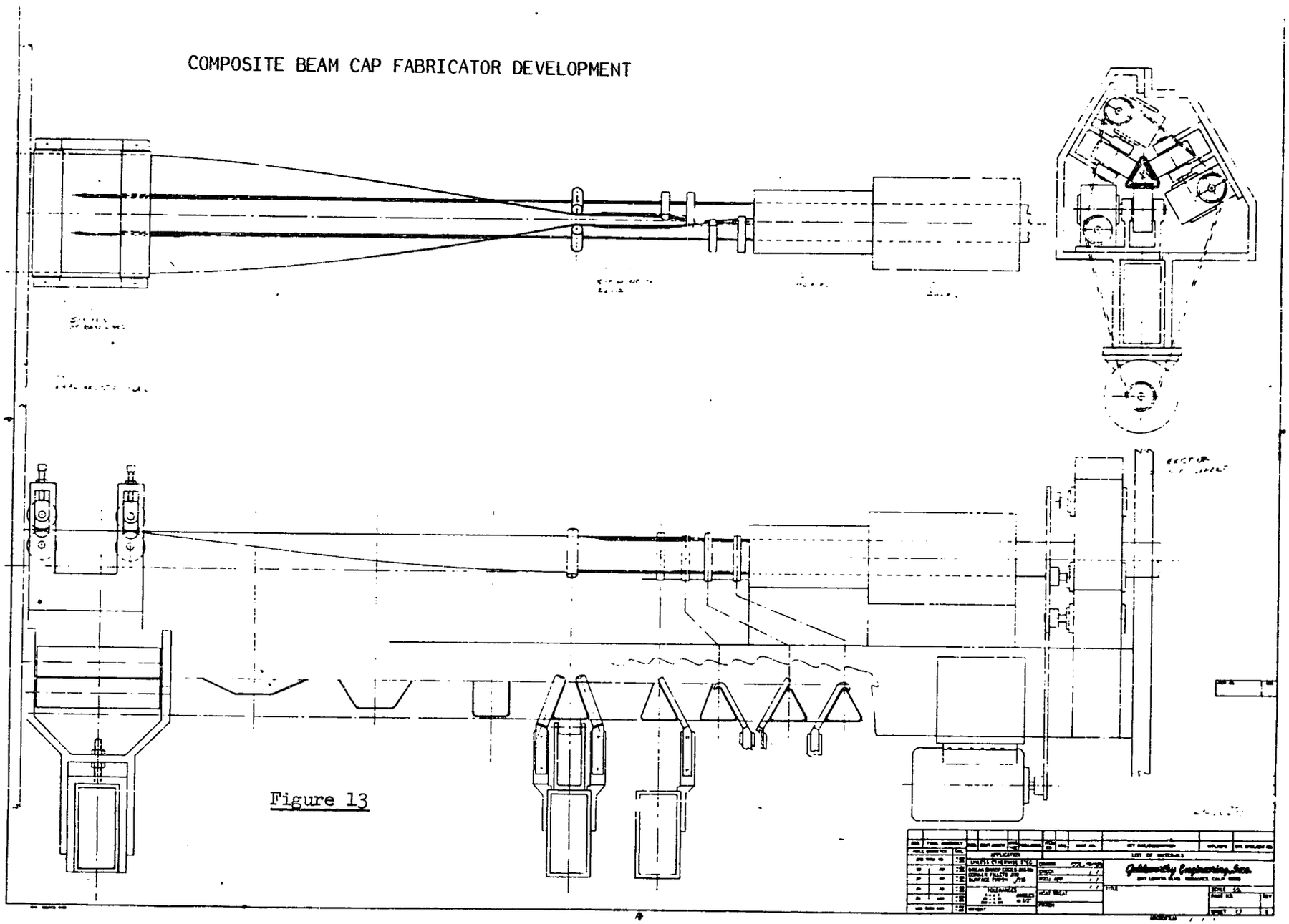


Figure 13

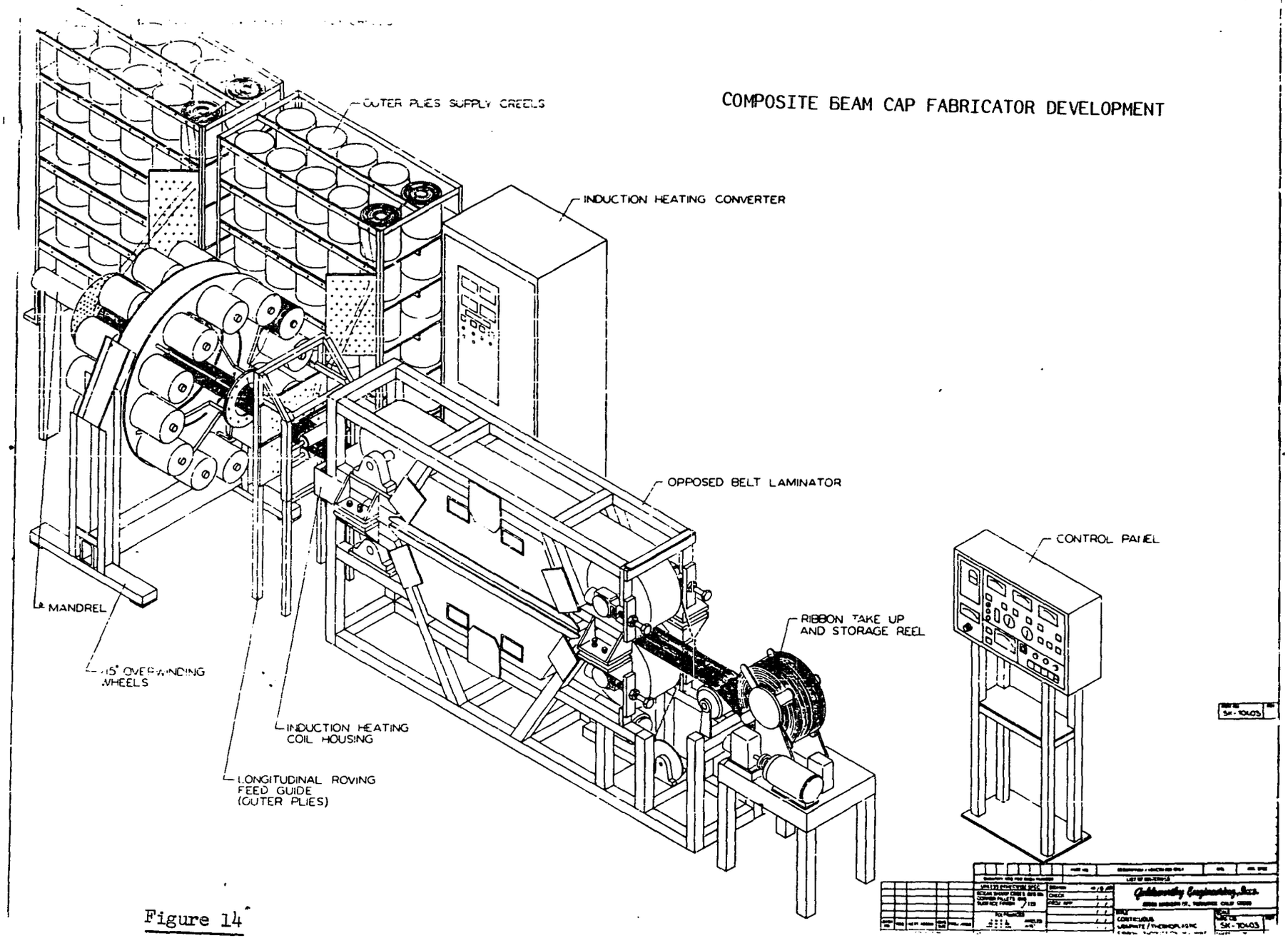

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT
OUTER PLIES SUPPLY CREELS
INDUCTION HEATING CONVERTER
OPPOSED BELT LAMINATOR
CONTROL PANEL
MANDREL
RIBBON TAKE UP AND STORAGE REEL
INDUCTION HEATING COIL HOUSING
LONGITUDINAL ROVING FEED GUIDE (OUTER PLIES)

Figure 14

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

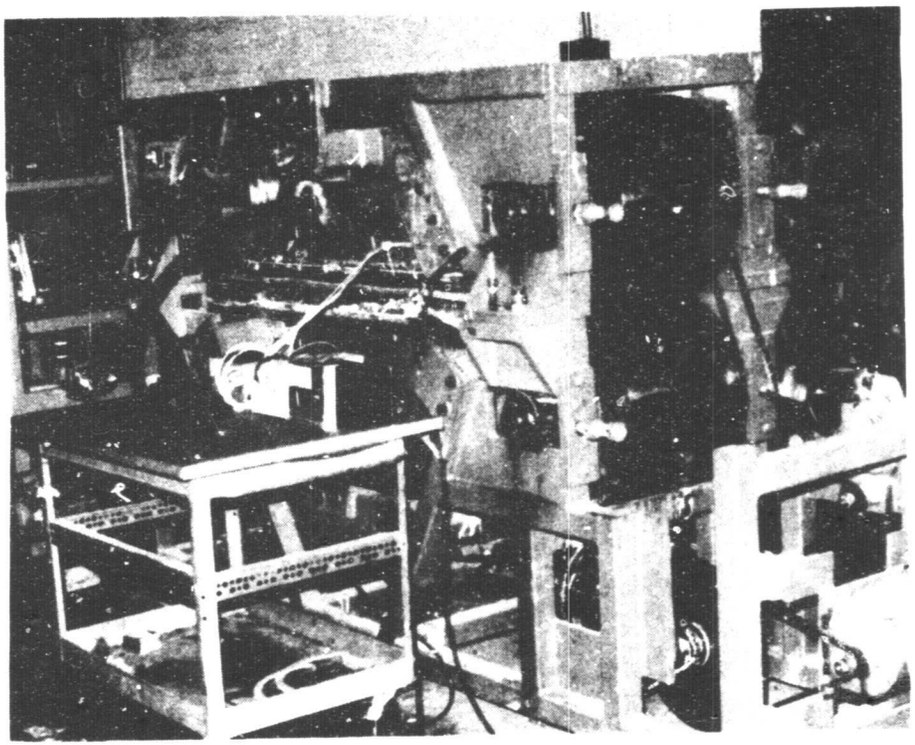
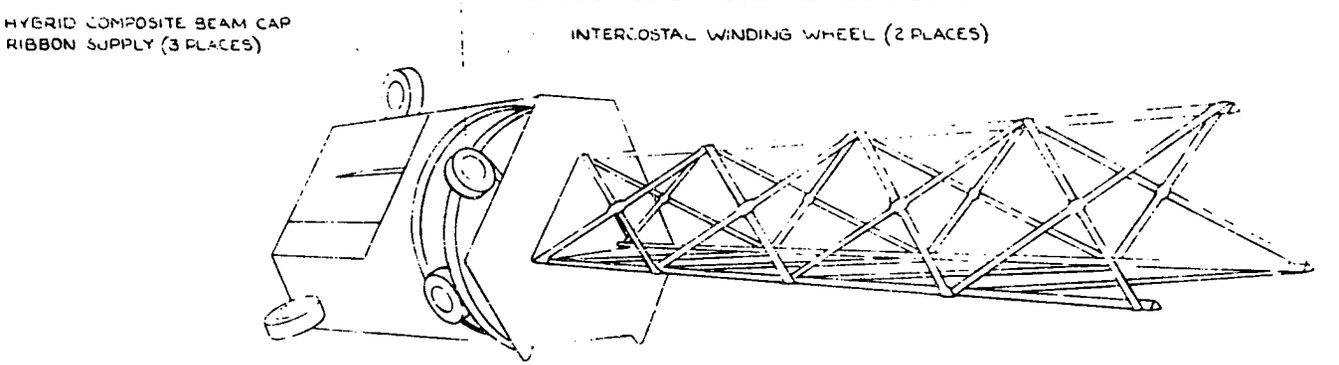


Figure 15

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT



BEAM MACHINE
CONTINUOUS INTERCOSTAL CONCEPT

Figure 16

CONCLUSION

WHAT HAVE WE LEARNED?

- MATERIALS AVAILABILITY
  - PREPREG IS LIMITED
  - CLOTH IS READILY AVAILABLE
  - LAMINATE IS DIFFICULT
- PULTRUSION PROCESS
  - THERMOSET
    - PRESENTS HANDLING DIFFICULTIES
    - 11 FT CAP LENGTH DEMONSTRATED
  - THERMOPLASTIC
    - EASY TO HANDLE
    - 8 FT RIBBON LENGTH DEMONSTRATED
    - 4 FT CAP LENGTH DEMONSTRATED
- CLOSED BEAM CAP CHARACTERISTICS
  - EXHIBITS LOW TRANSVERSE STRENGTH AT PRESENT

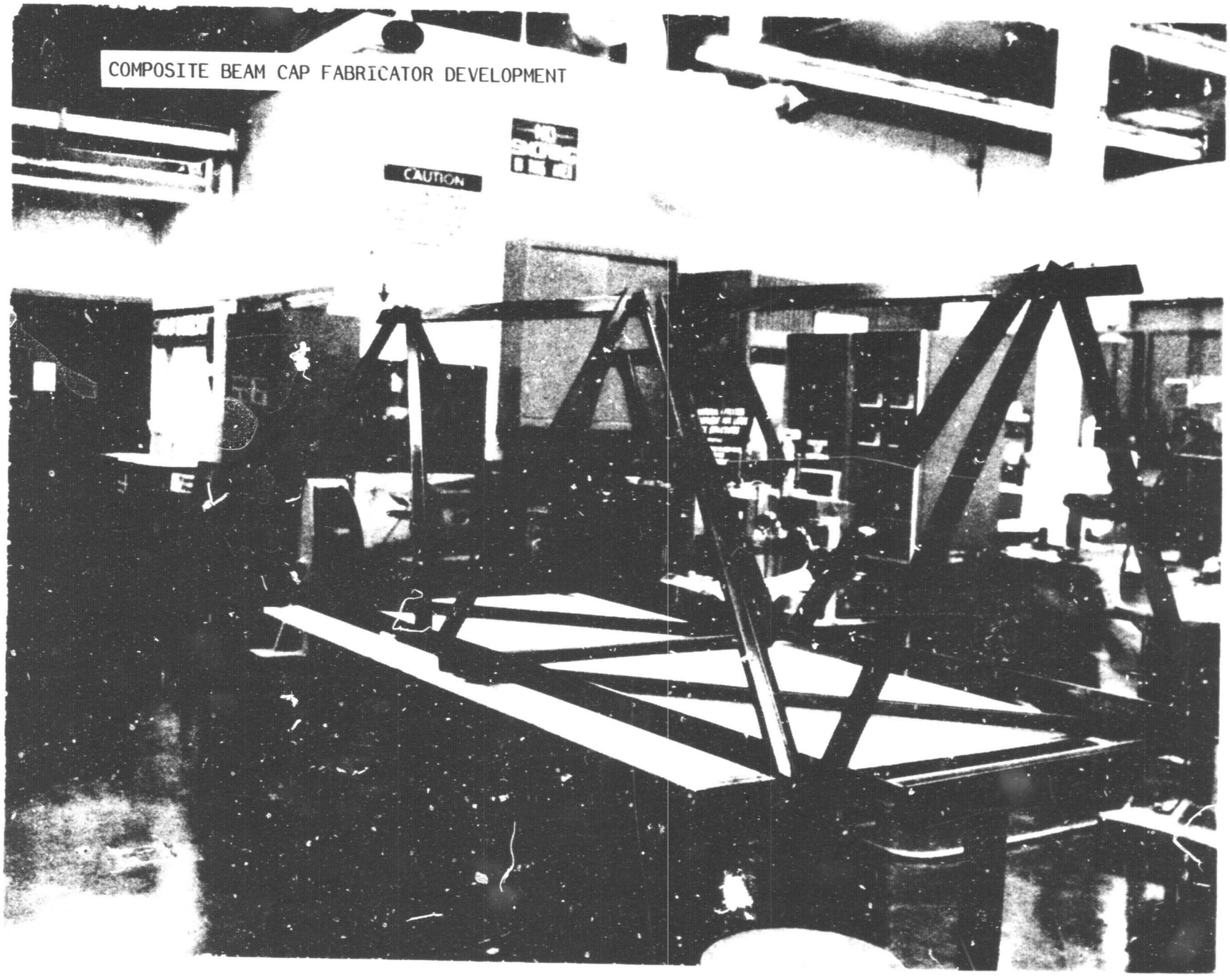


Figure 17

ENCLOSURE (2)

SPACE FABRICATION DEMONSTRATION SYSTEM

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

PHASE I & II FINAL REPORT

SPACE FABRICATION DEMONSTRATION SYSTEM

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

PHASE I & II FINAL REPORT

PRESENTED TO
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
OCTOBER 24, 1979

Goldsworthy

GRUMMAN

1618-101B

COMPOSITE BEAM CAP FABRICATOR
NASA-MSFC CONTRACT NAS 8-32472

AGENDA

- OVERVIEW
- PROCESS DEVELOPMENT
- PROCESS EVALUATION
- BEAM CAP FABRICATOR CONFIGURATION
- SUMMARY

OVERVIEW

COMPOSITE BEAM CAP FABRICATOR

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  - CONTRACTING OFFICER REPRESENTATIVE – ERICH E. ENGLER
- PRIME CONTRACTOR – GRUMMAN AEROSPACE CORPORATION
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7/18/79 MEETING
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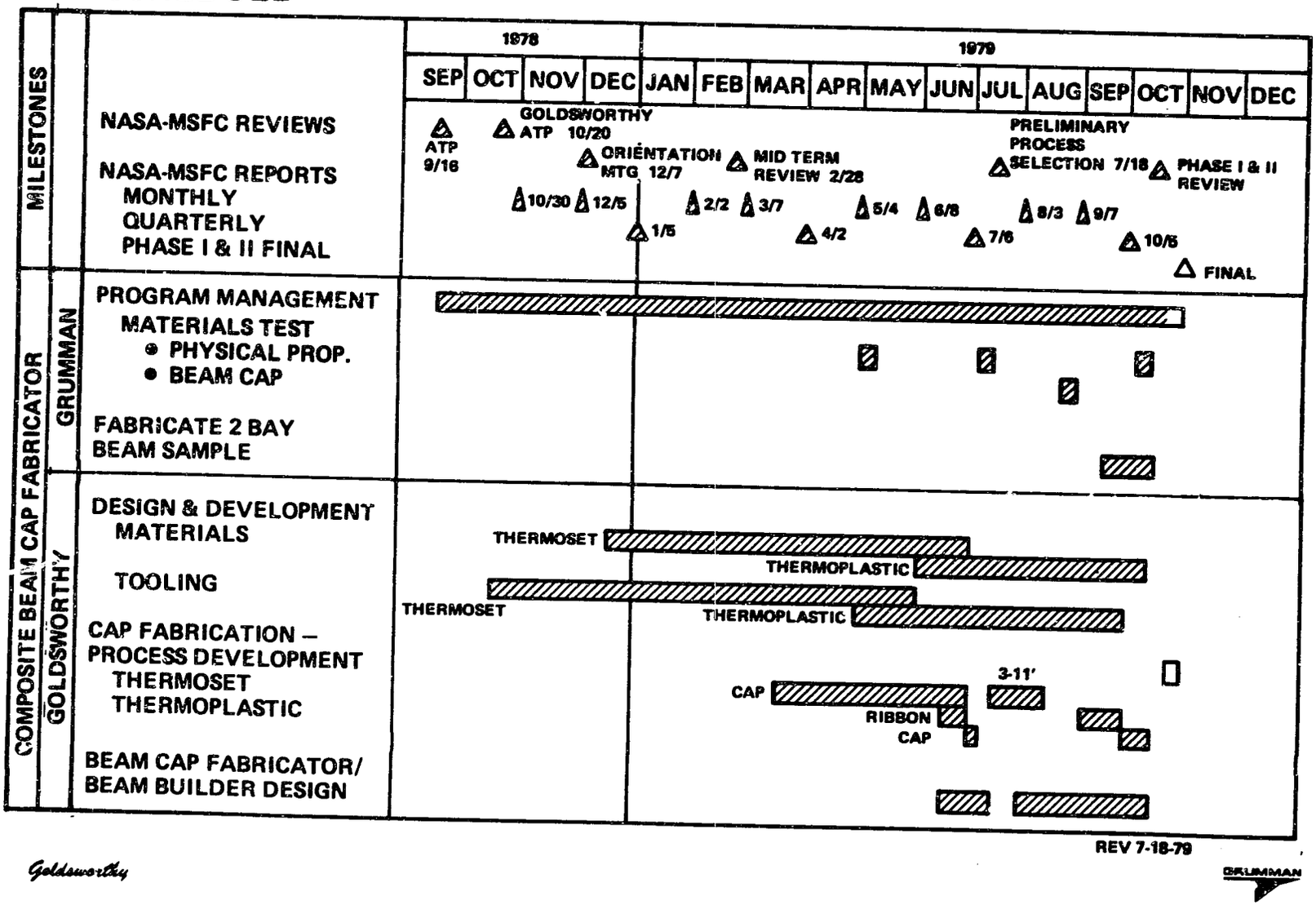
  - BEAM CAP/CROSS BRACE FASTENING TECHNIQUE IDENTIFICATION
  - BEAM CUT-OFF METHOD

COMPOSITE BEAM CAP FABRICATOR

SCHEDULE



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1618-126B

COMPOSITE BEAM CAP FABRICATOR
NASA-MSFC CONTRACT NAS 8-32472

AGENDA

- OVERVIEW
- **PROCESS DEVELOPMENT**
- PROCESS EVALUATION
- BEAM CAP FABRICATOR CONFIGURATION
- SUMMARY

PROCESS DEVELOPMENT

PHASE I

- MATERIAL INVESTIGATION & SELECTION
  - THERMOSET
  - THERMOPLASTIC
- PULTRUSION DEVELOPMENT
  - THERMOSET MATERIAL (DROPPED 7-18-79)
    - OPEN BEAM CAP
    - CLOSED BEAM CAP
  - THERMOPLASTIC MATERIAL
    - RIBBON FABRICATION
    - BEAM CAP FORMING
      - CLOSED BEAM CAP
      - OPEN BEAM CAP (DROPPED 7-18-79)

PHASE II

- CONCEPTUAL MACHINE DESIGN
  - RIBBON FABRICATION EQUIPMENT
  - BEAM CAP FABRICATOR
    - GRUMMAN BEAM BUILDER RELATIONSHIP (INSTALLATION, FASTENING, CUT-OFF, ETC)

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

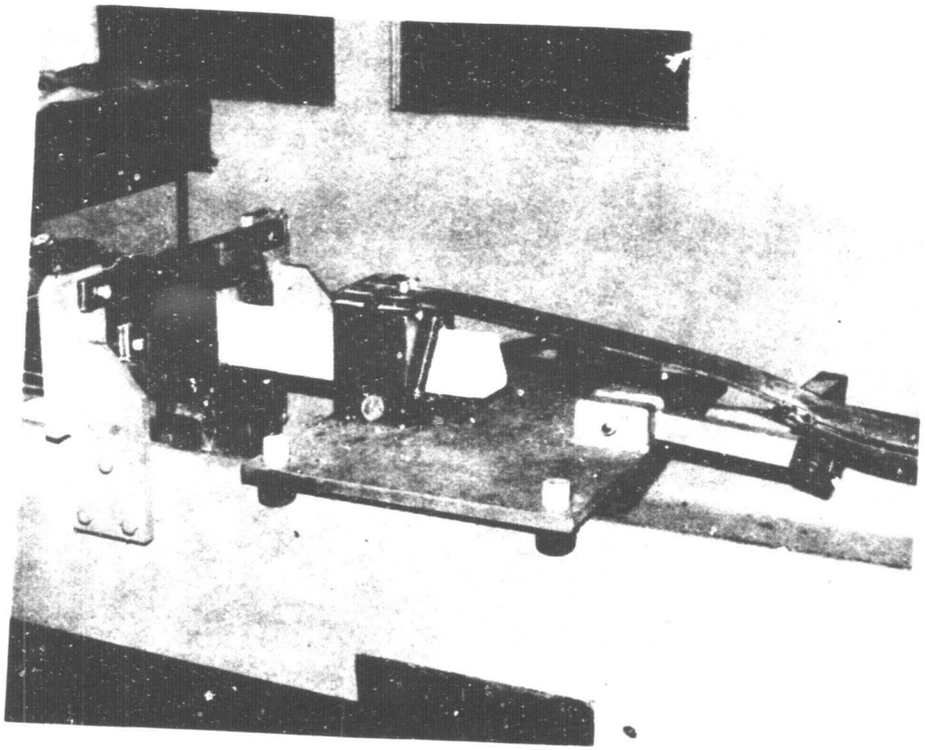


Figure 1

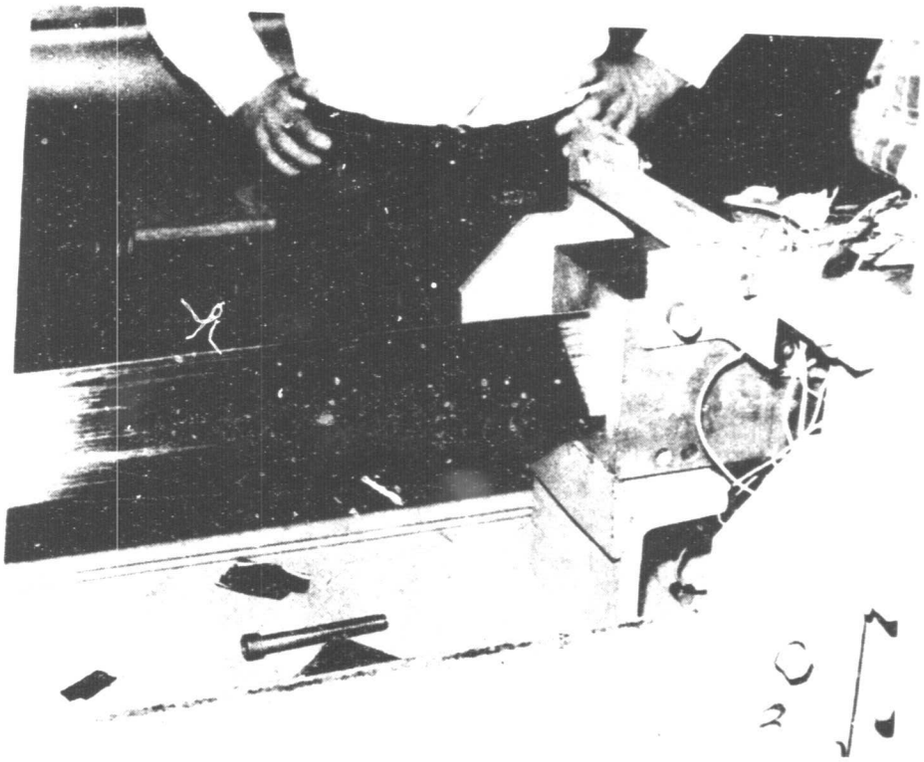


Figure 2

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

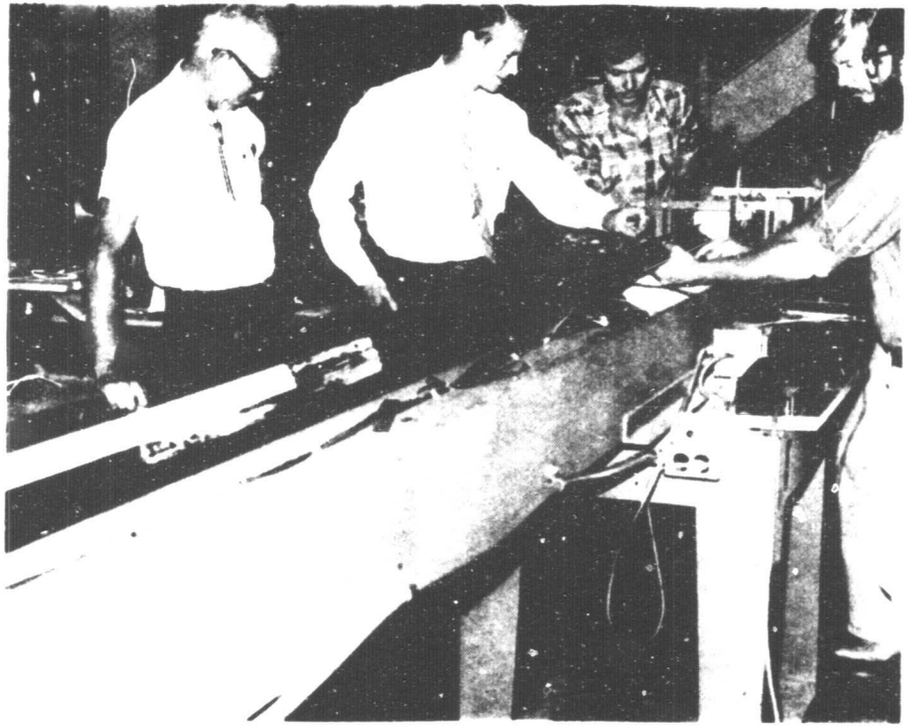


Figure 3

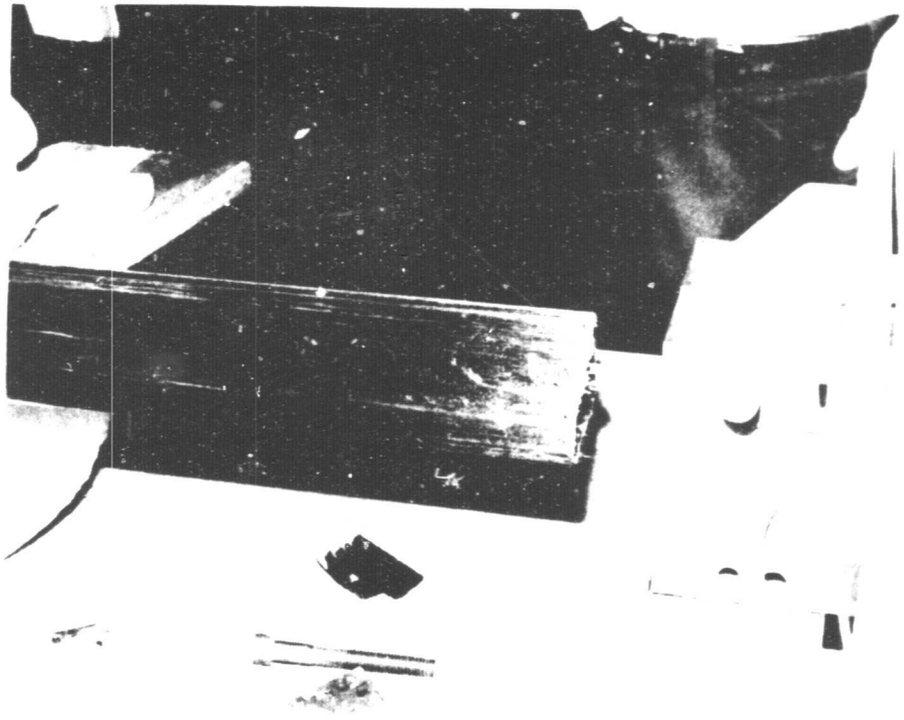


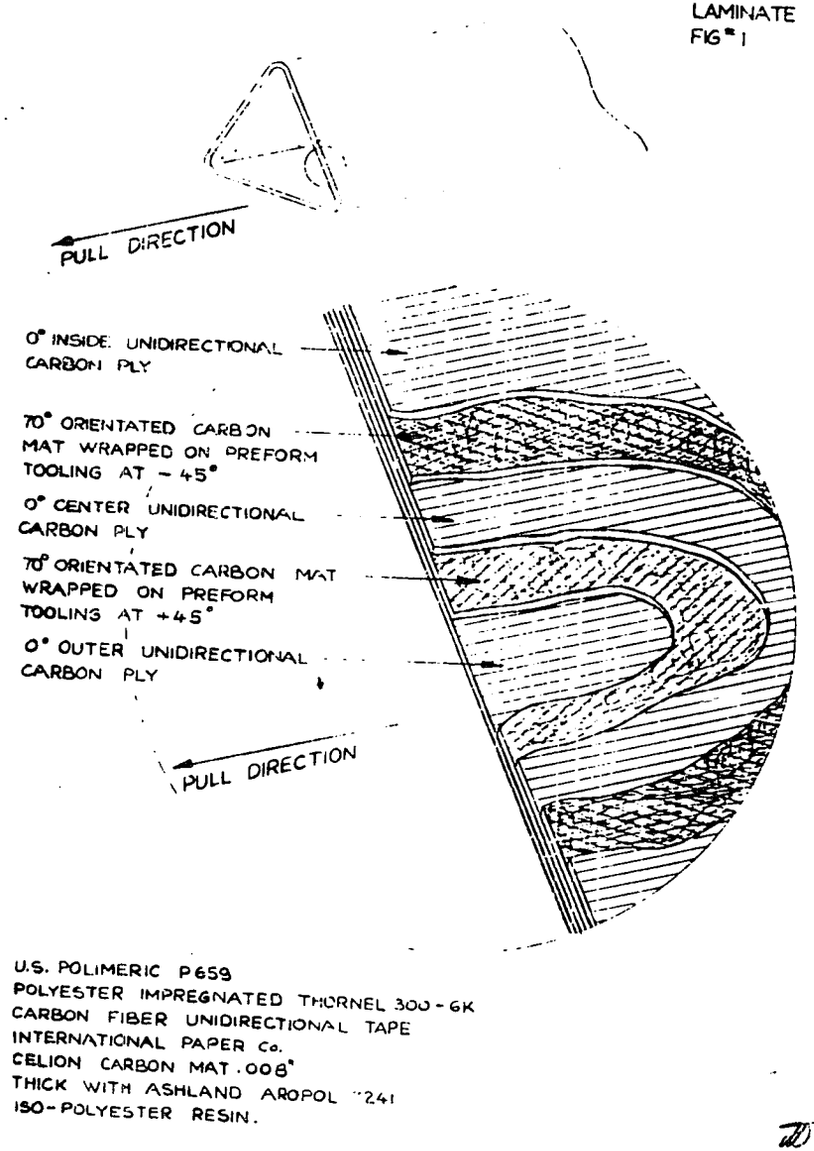
Figure 4

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

Figure 5

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

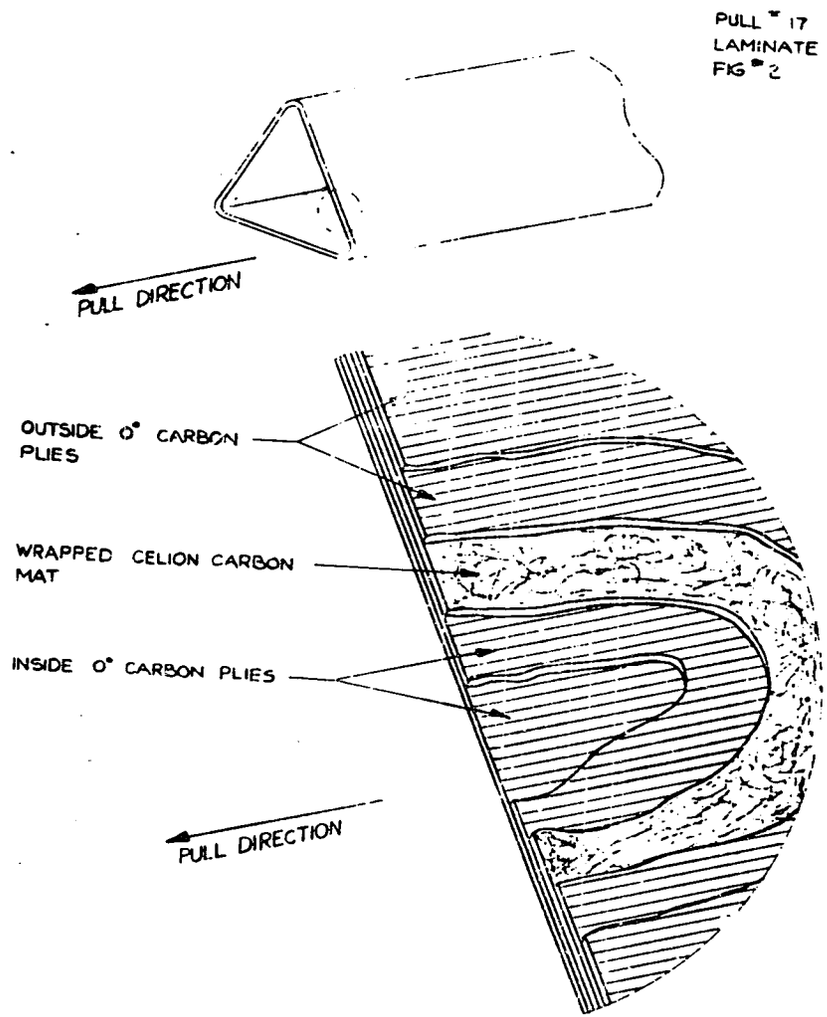
PULL # 16
LAMINATE SCHEDULE
FIG # 1



U.S. POLIMERIC P659
POLYESTER IMPREGNATED THORNEL 300 - 6K
CARBON FIBER UNIDIRECTIONAL TAPE
INTERNATIONAL PAPER Co.
CELION CARBON MAT .008"
THICK WITH ASHLAND AROPOL 7241
ISO-POLYESTER RESIN.

Figure 6

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT



U.S. POLYMERIC P 656.
POLYESTER IMPREGNATED THORNEL 300-6K UNIDIRECTIONAL TAPE.
ASHLAND AROPOL 7241 POLYESTER IMPREGNATION OF THE CELION CARBON MAT

Figure 7

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

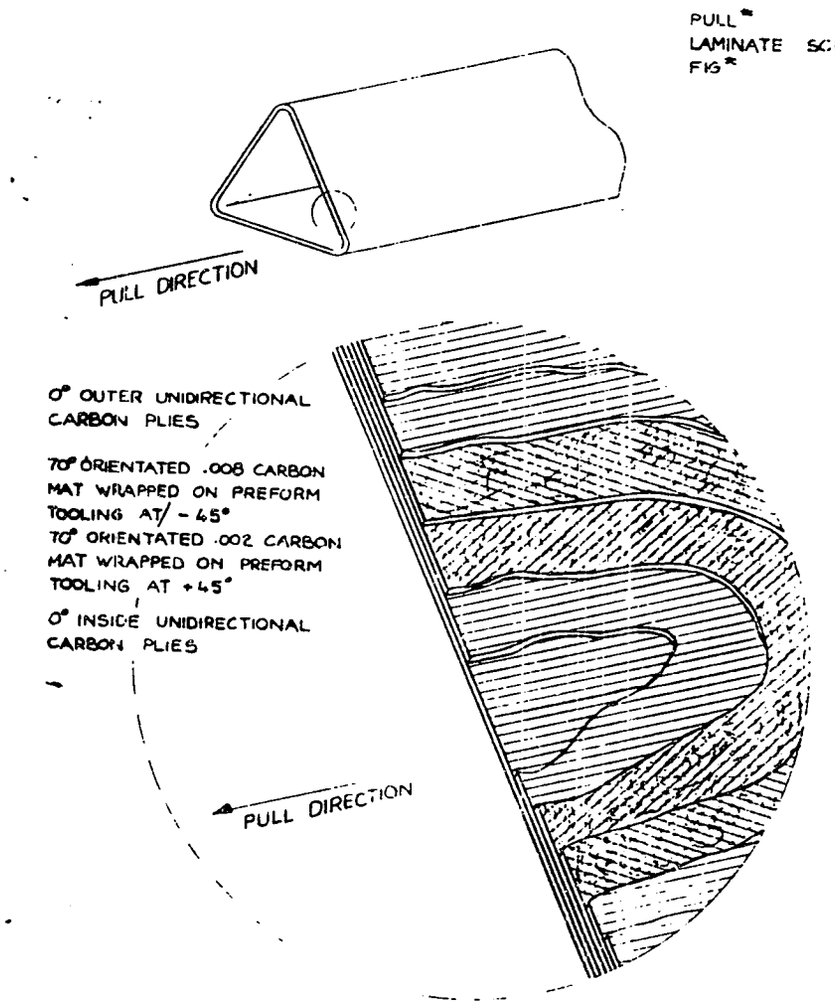
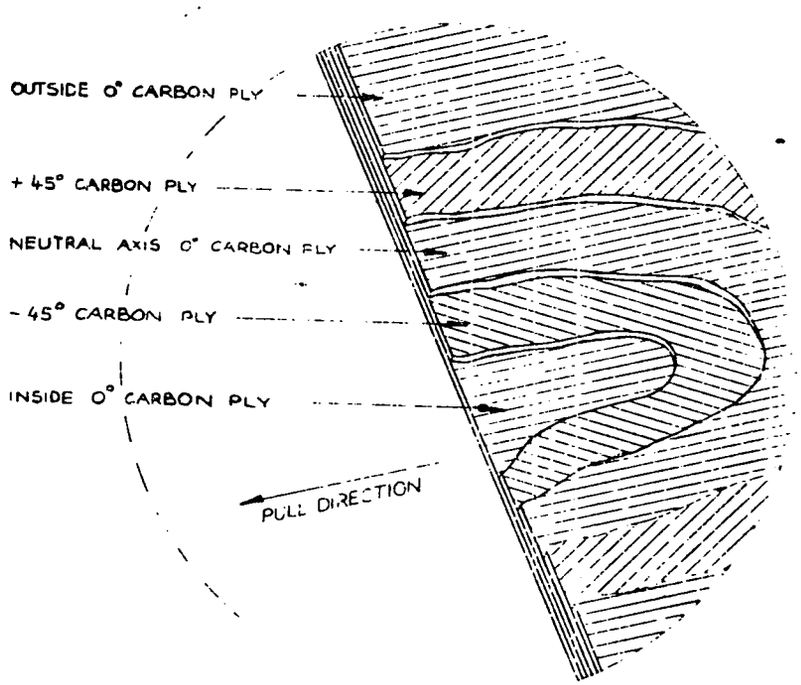


Figure 8

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

THERMOPLASTIC LAMINATE SCHEDULE
FIG # 1



U.S. POLYMERIC P1700
POLYSULFONE

Figure 9

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

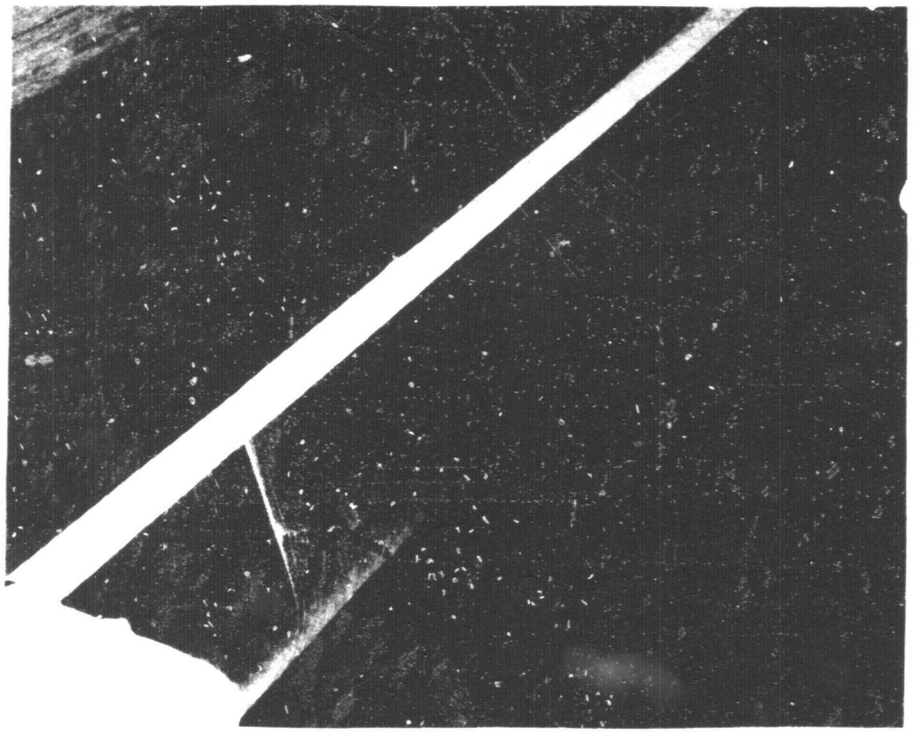


Figure 10

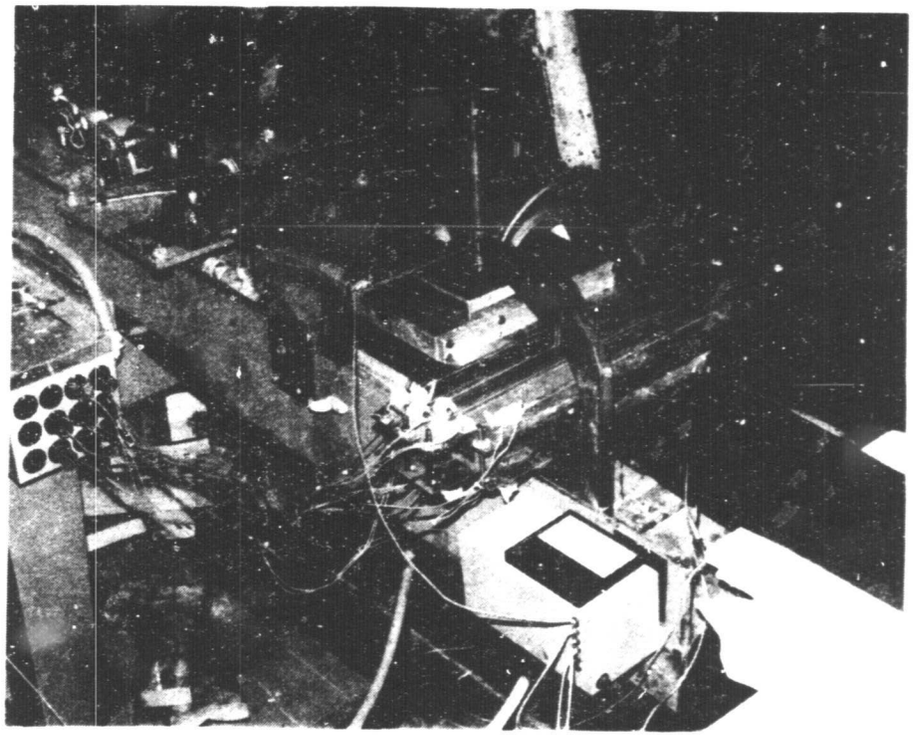


Figure 11

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

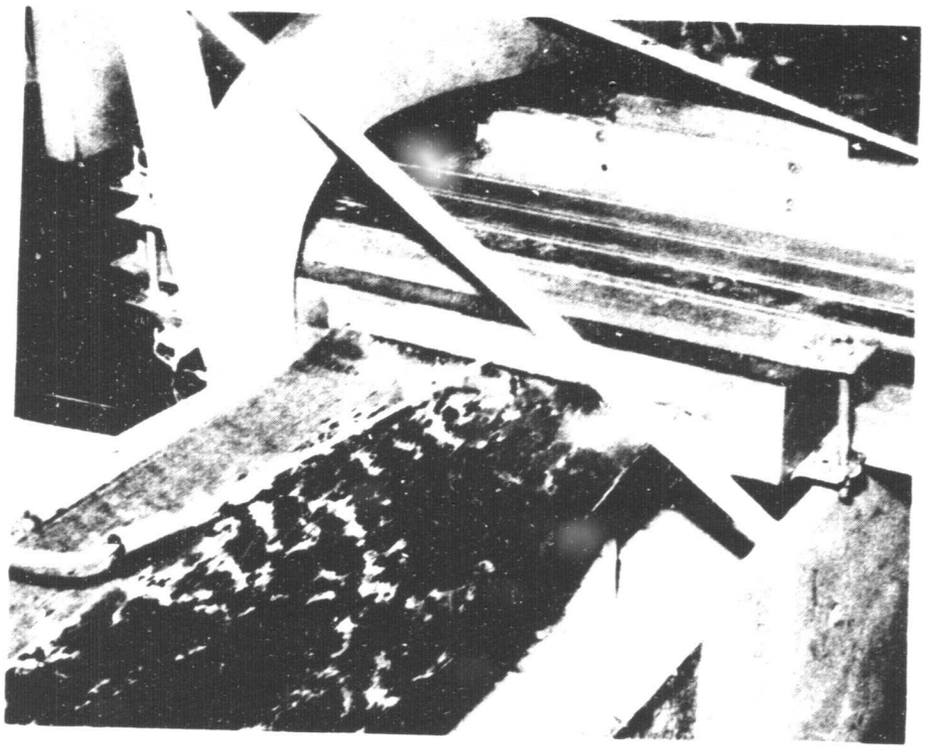


Figure 12

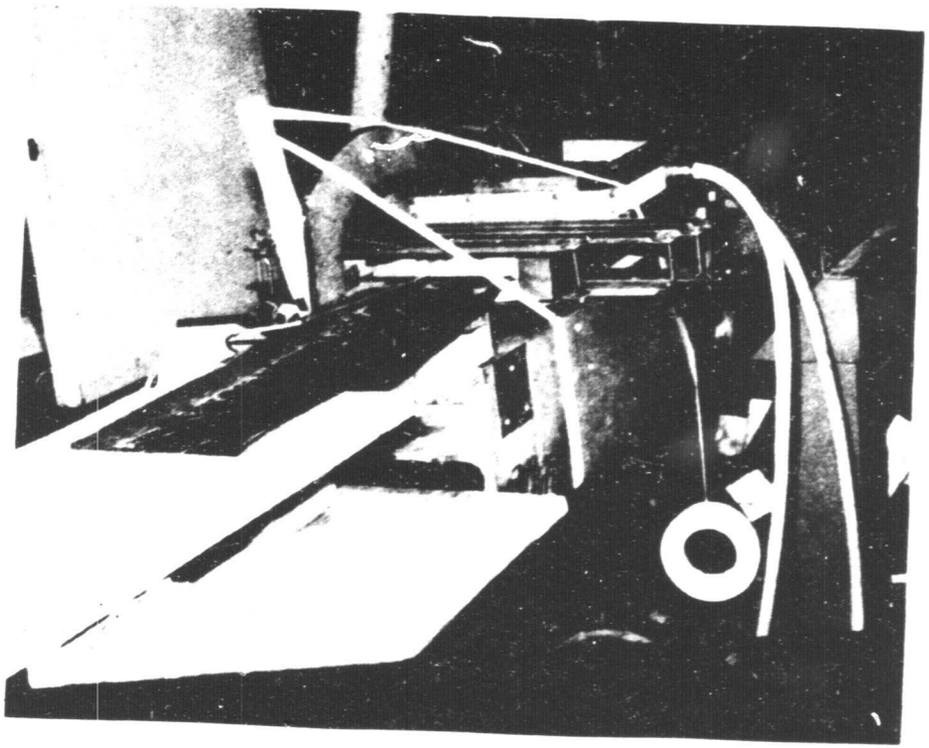


Figure 13

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

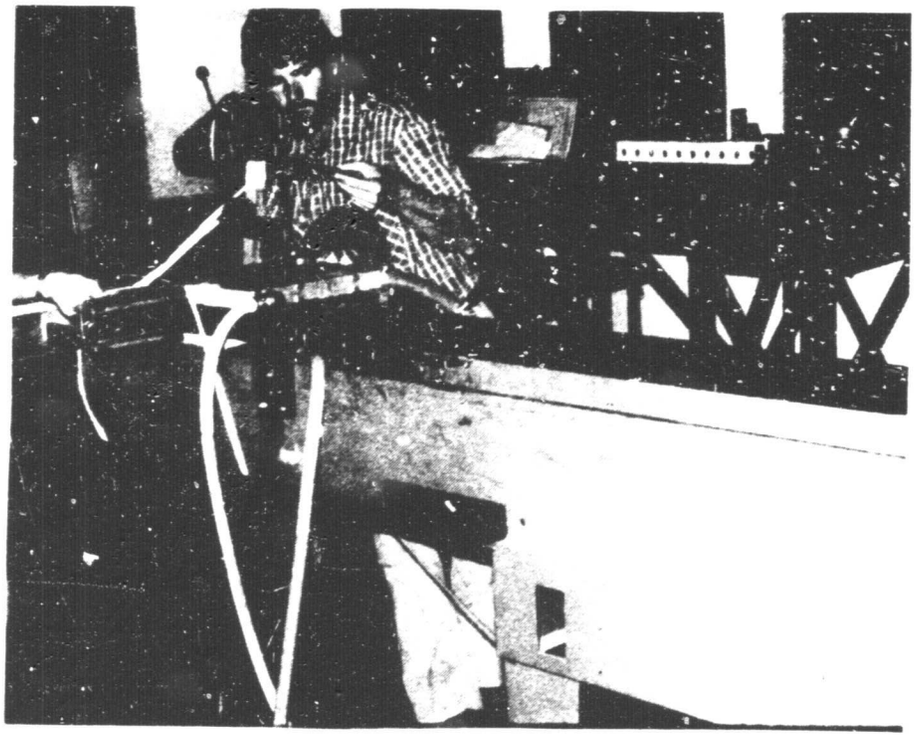


Figure 14

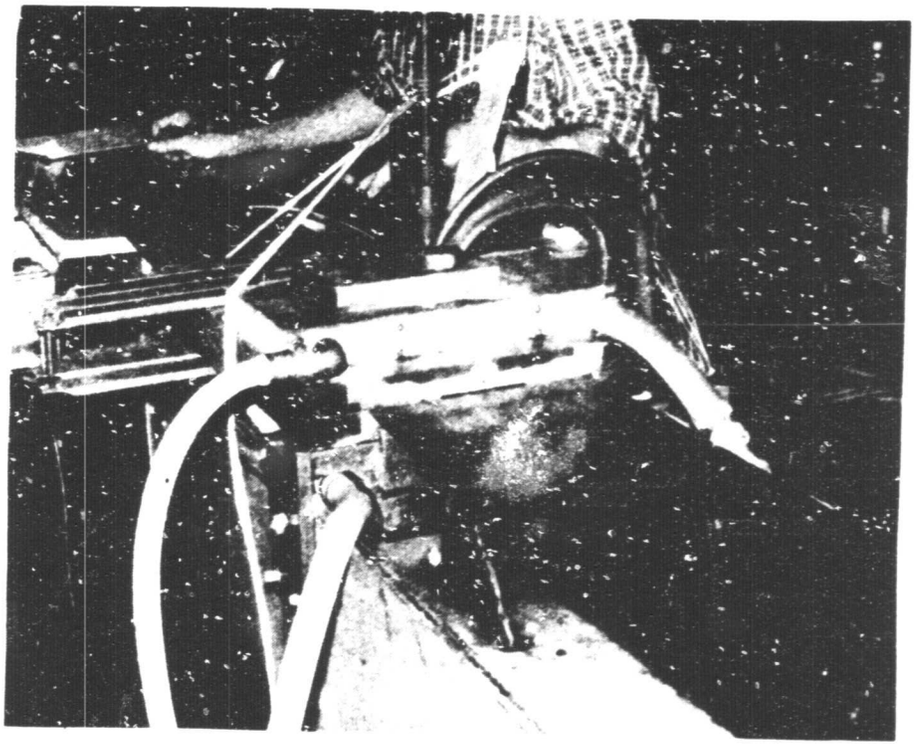


Figure 15

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

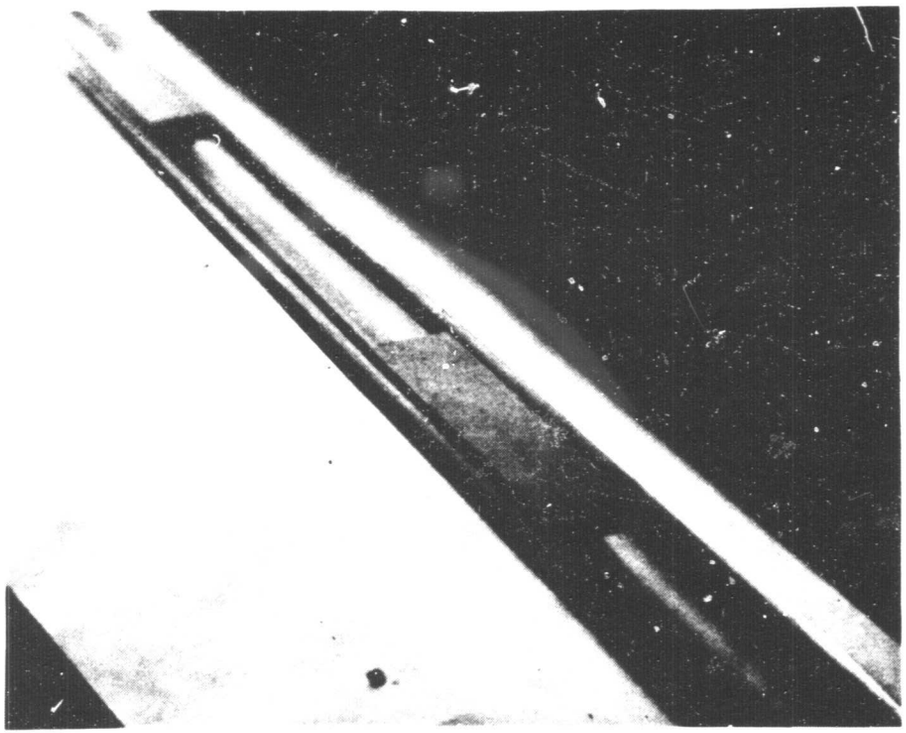


Figure 16

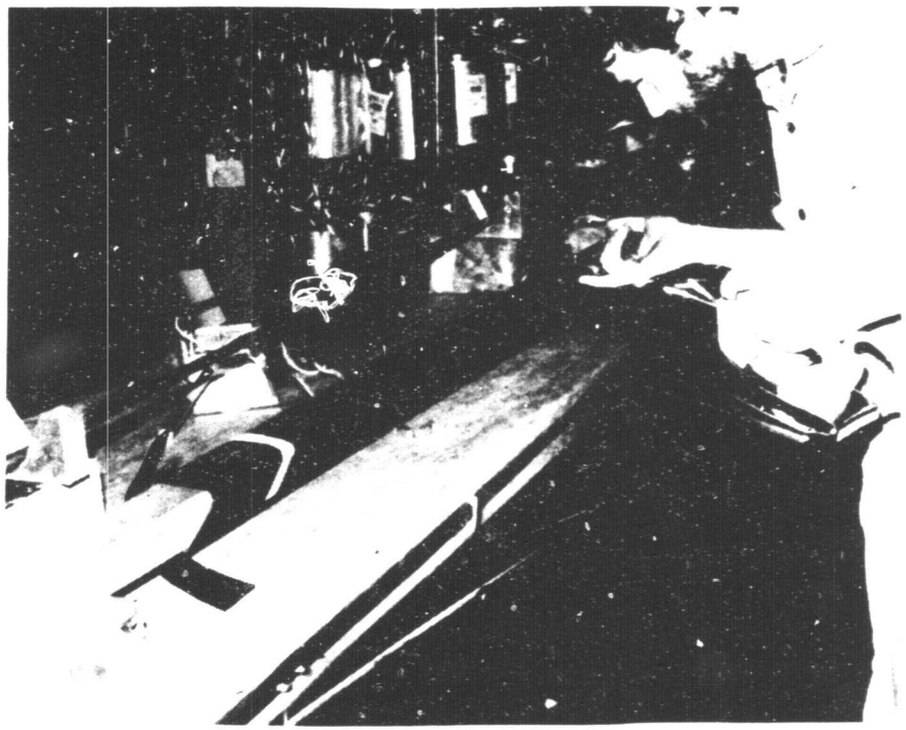


Figure 17

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

Figure 18

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

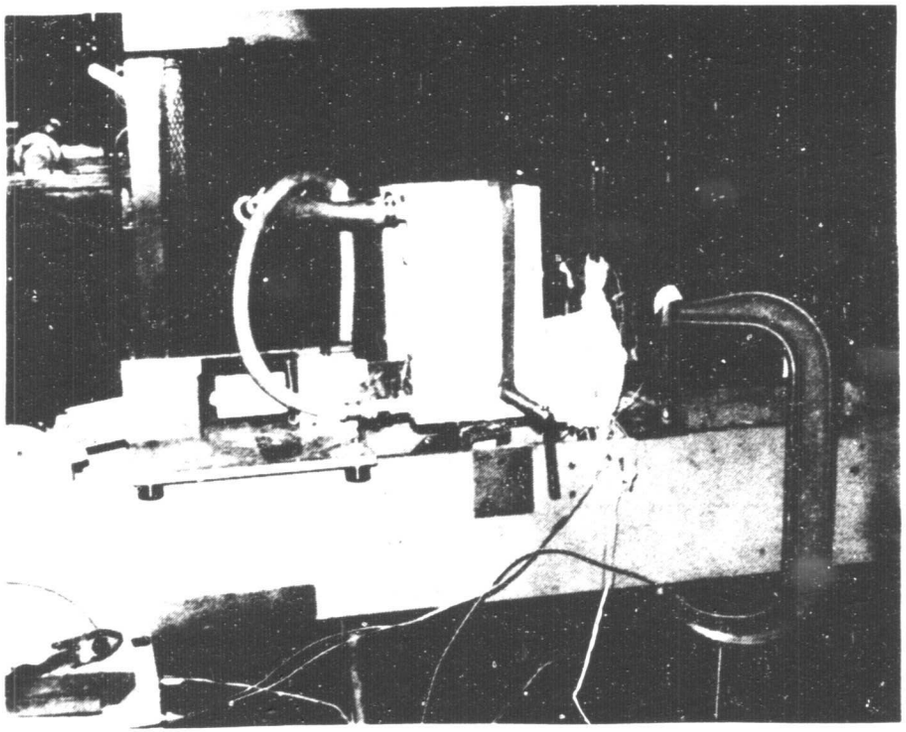


Figure 19

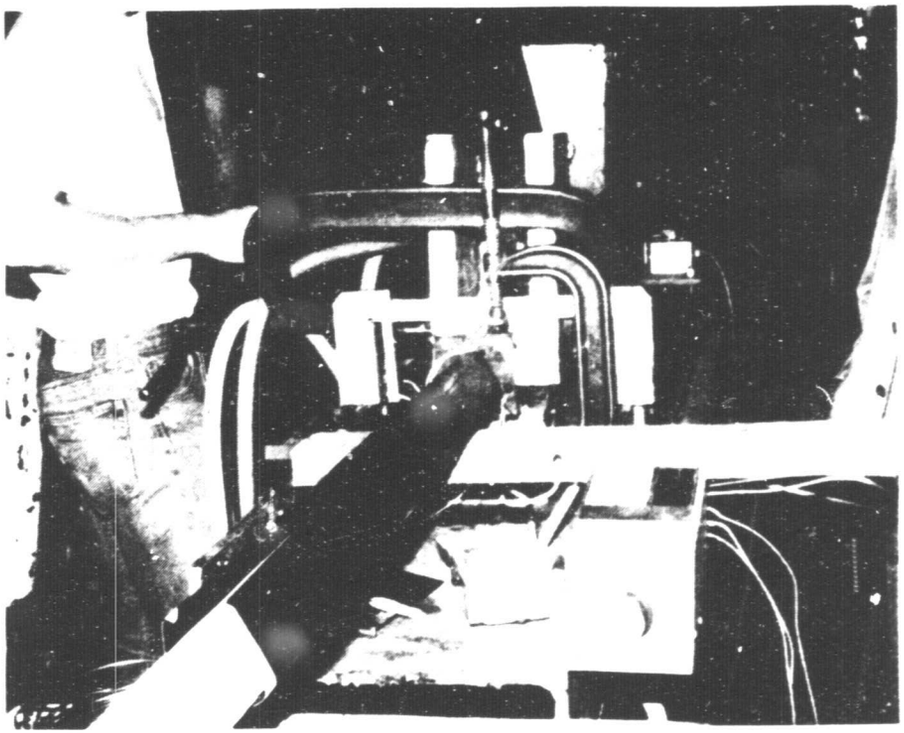


Figure 20

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

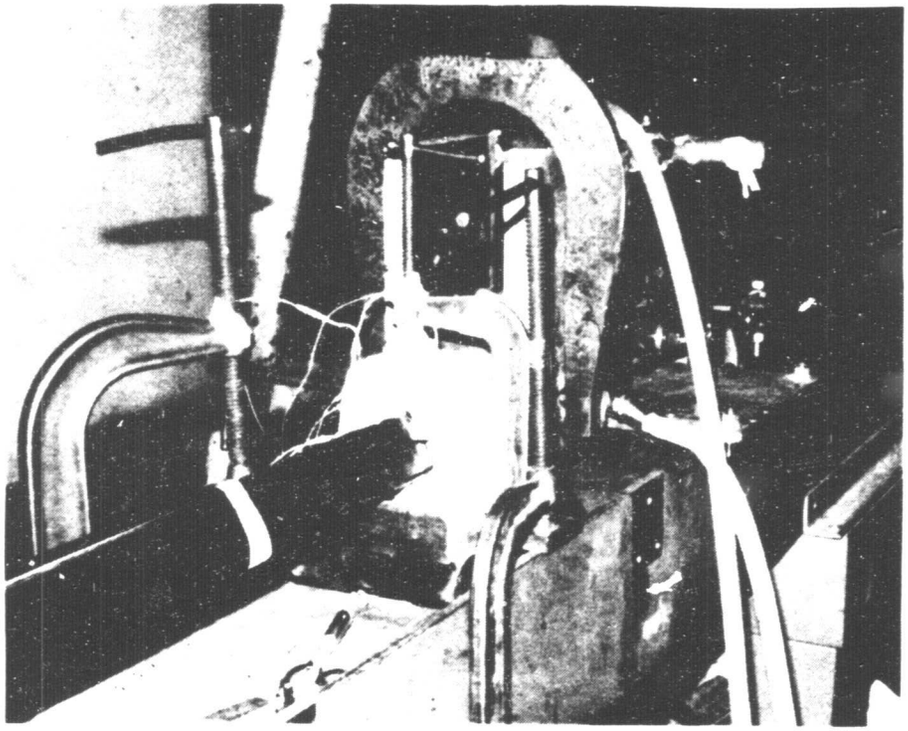


Figure 21

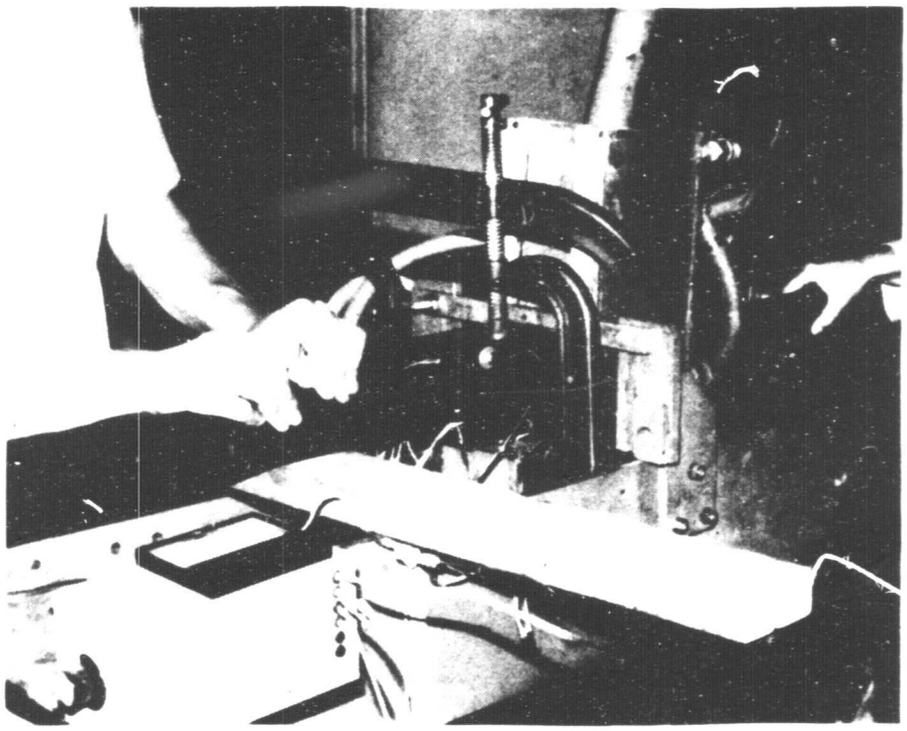


Figure 22

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

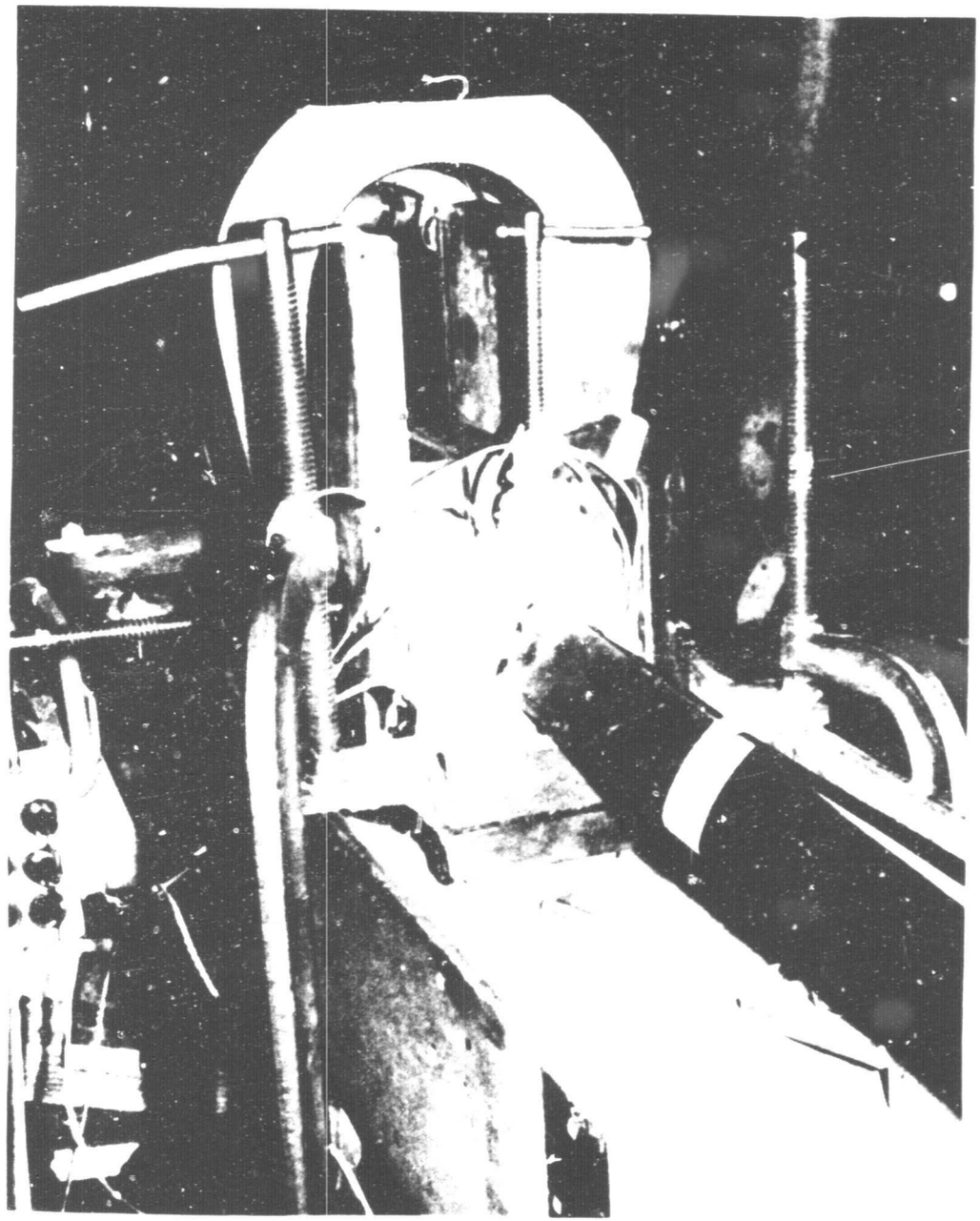


Figure 23

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

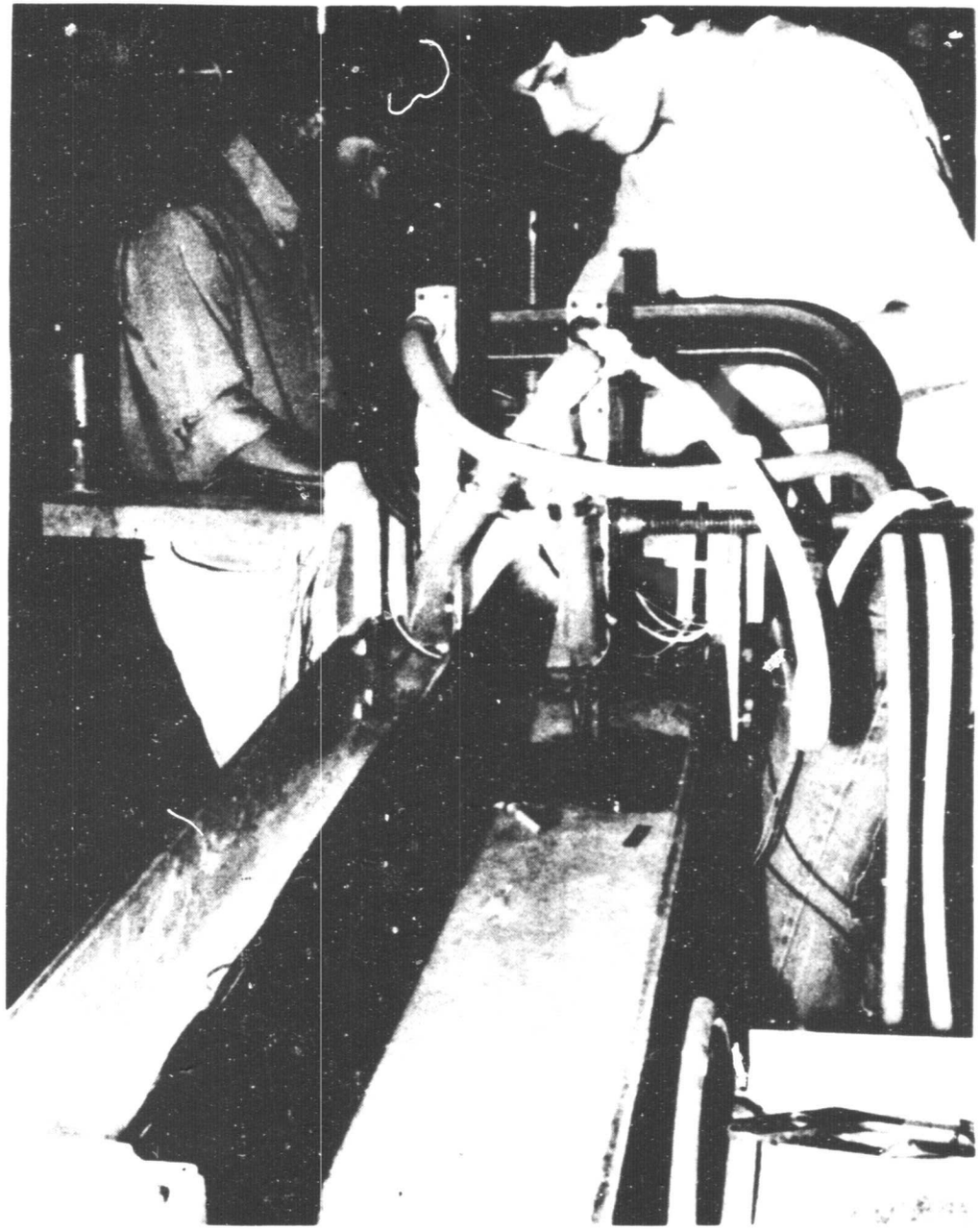


Figure 24

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

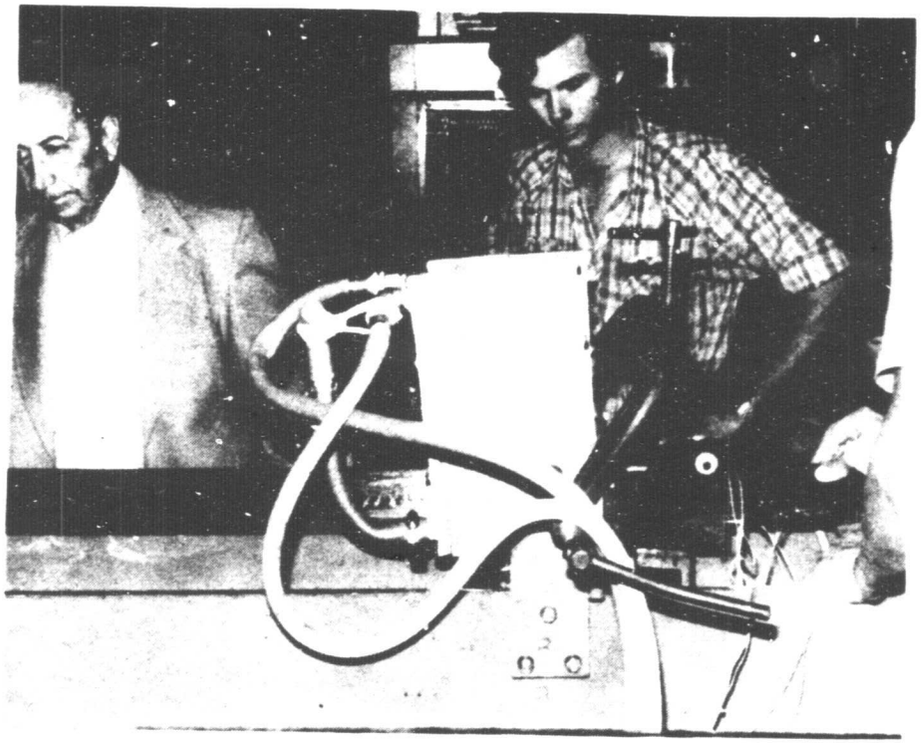


Figure 25

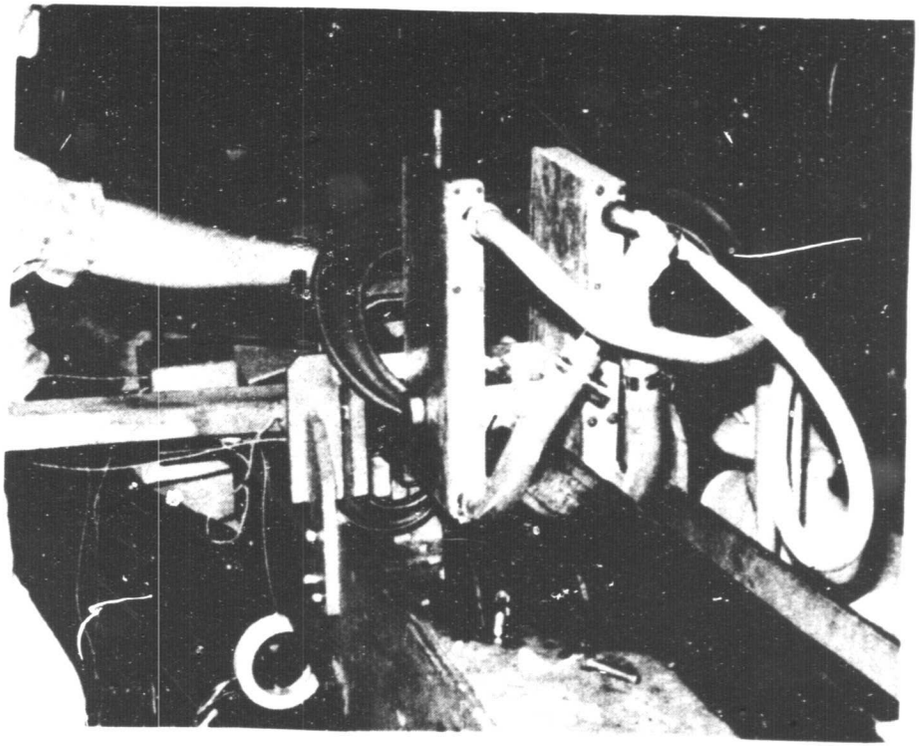


Figure 26

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

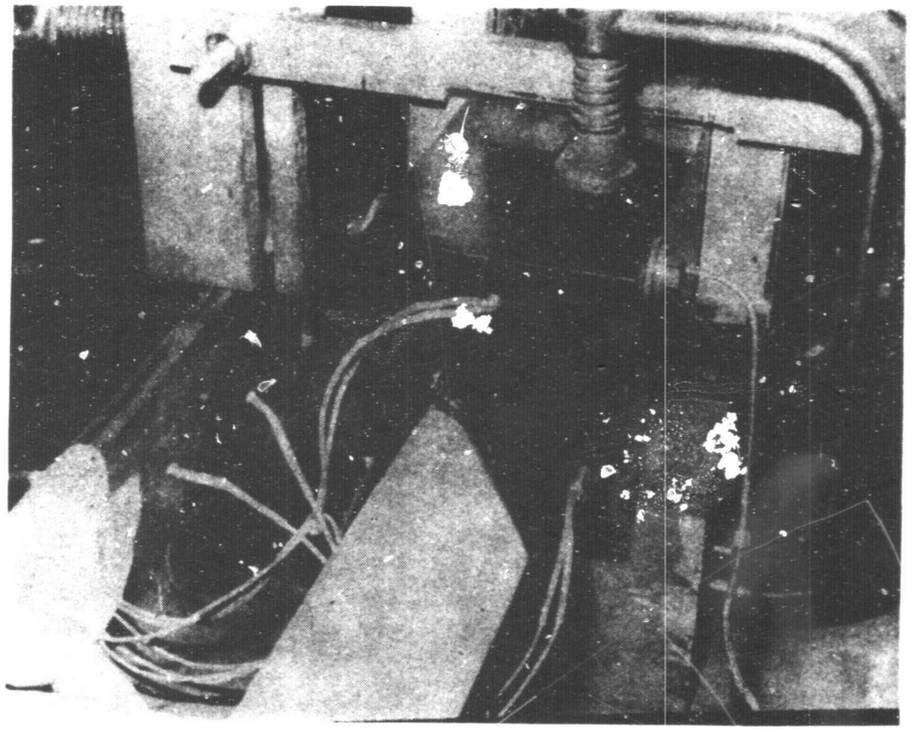


Figure 27

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

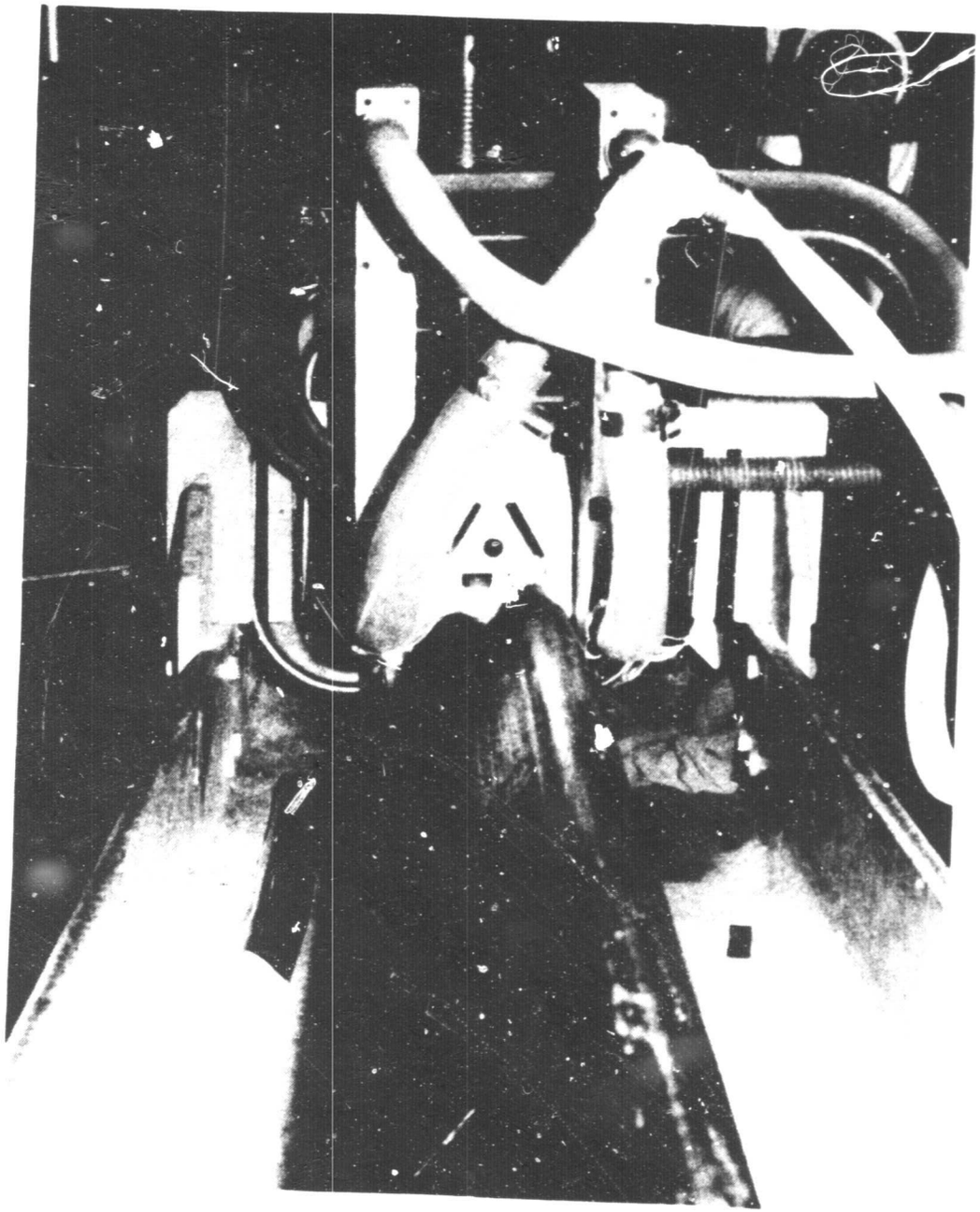


Figure 28

COMPOSITE BEAM CAP FABRICATOR
NASA-MSFC CONTRACT NAS 8-32472

AGENDA

- OVERVIEW
- PROCESS DEVELOPMENT
- PROCESS EVALUATION
- BEAM CAP FABRICATOR CONFIGURATION
- SUMMARY

PROCESS EVALUATION

GRUMMAN M&P LABORATORY DATA

MATERIALS PROPERTIES TESTING OF CANDIDATE GRAPHITE & LAMINATES

	REINFORCEMENT DESCRIPTION	RESIN DESCRIPTION	LAMINATE STACKING SEQUENCE	THICK-NESS	LONG. TENSION STRENGTH (KSI)		LONG. TENSION MODULUS (MSI)		FLEXURAL STRENGTH (KSI)				FLEXURAL MODULUS (MSI)			
									LONG. 0°		90° TRANS		LONG 0°		90° TRANS	
					RT	170°F	RT	170°F	RT	250°F	RT	250°F	RT	250°F	RT	250°F
THERMOSET	THORNEL 6K GRAPHITE WITH GLASS SCRIM/CELION CARBON MAT CORE	HEXCEL F-549 POLYESTER	0°/CARBON MAT/0°	0.024	66.9	94.1	9.3	9.9								
	THORNEL 6K GRAPHITE WITH GLASS SCRIM	HEXCEL F-549 POLYESTER	0°/0°/0°	0.043	59.8	55.1	7.6	6.1								
	CELANESE 6K GRAPHITE	DAP POLYESTER	0°/45°/135°/0°	0.034	72.4	66.8	8.1	8.4								
	CELANESE 6K GRAPHITE	DAP POLYESTER	0°/45°/0°/135°/0°	0.035	113.2	107.1	11.2	11.1								
	THORNEL 6K GRAPHITE WITH GLASS SCRIM/CARBON & KEVLAR MAT	HEXCEL F-549 POLYESTER	0°/CARBON-KEVLAR-MAT/0°	0.027	82.0	60.1	8.6	7.5								
	PAN GRAPHITE/CARBON MAT (CLOSED BEAM)	POLYESTER	0°/135° CARBON MAT/ 0°/45° CARBON MAT/0°	0.031 TO 0.034	111.5	56.7(2)	14.9	14.5(2)	231.8	63.2	8.1	2.6	14.9	6.9	0.1 (1)	0.2(1)
THERMOPLASTIC	PAN GRAPHITE	POLYETHER-SULFONE	0°/135°/45°/0°	0.026	86.3	86.4	9.6	9.0								
	PAN GRAPHITE(3)	P1700 POLYSULFONE	0°/0°/45°/135°/0°/0°	0.036					103.8	119.6	8.9	5.7	12.2	15.6	0.4	0.3
	PAN G. APHITE(4)	P1700 POLYSULFONE	0°/0°/45°/135°/0°/0°	0.035					176.0	125.6	13.7	10.8	16.0	14.8	0.5	0.7
	ALUMINUM	BASELINE		0.016	47.0	47.0	10.5	10.5	NA				NA			

NOTE: 1. MODULUS PLOT TOO LOW AND ERRATIC TO MEASURE
2. TESTED @ 250°F
3. PROCESSED AT 575°F/100 #PULL FORCE/12 IPM
4. PROCESSED AT 600°F/375 #PULL FORCE/10 IPM

Goldsworthy

GRUMMAN

1618-111B

PROCESS EVALUATION

GRUMMAN LABORATORY DATA

BEAM CAP PROPERTIES

MATERIAL TYPE IDENTITY LAY-UP	COMPOSITE THERMOSET GR/PE 0°-0°±45°M-0°-0°	COMPOSITE THERMOPLASTIC GR/PS 0°-0°±45°-0°-0°	METAL ALUMINUM 2024-T3
TYPE OF CAP			
THICKNESS, IN. WEIGHT, LBS/FT DESIGN ULTIMATE LOAD, LBS FAILURE LOAD, LBS	0.038 0.17 — 720*	0.035 0.17 — ?	0.016 0.12 433 505*
TENSILE STRENGTH LONG, KSI TENSILE MODULUS LONG, MSI FLEXURE STRENGTH LONG, KSI FLEXURE MODULUS LONG, MSI	111.5 12.8 231.8 14.9	— — 176.0 16.0	47 10.5 NA NA
FLEXURE STRENGTH TRANS, KSI FLEXURE MODULUS TRANS, MSI	8.1 **	13.7 0.5	NA NA

*SPECIMEN LENGTH = 59.05 IN
**MODULUS TOO LOW TO MEASURE

Goldsworthy

GRUMMAN

1618-1238

COMPOSITE BEAM CAP FABRICATOR
NASA-MSFC CONTRACT NAS 8-32472

AGENDA

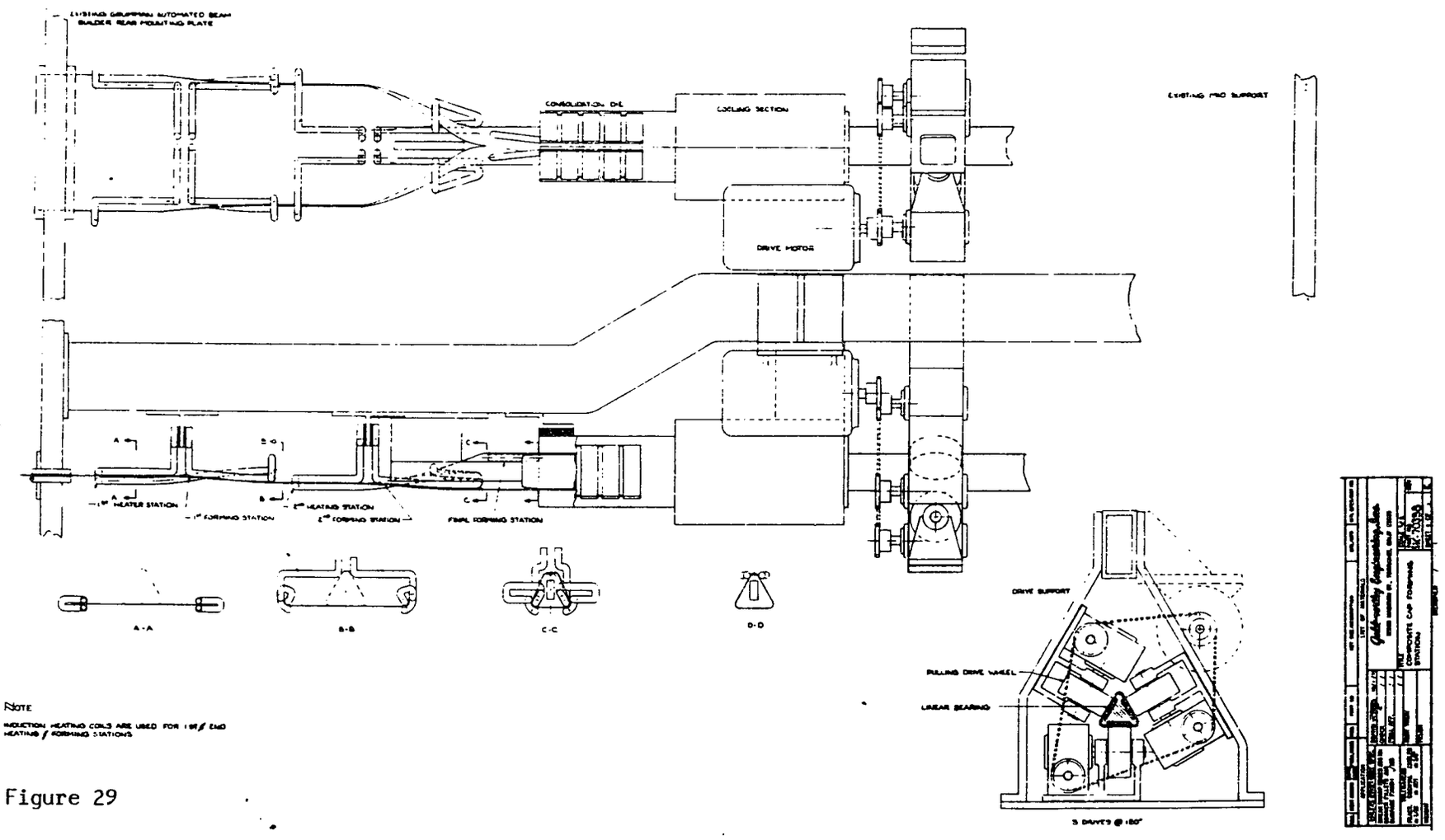
- OVERVIEW
- PROCESS DEVELOPMENT
- PROCESS EVALUATION
- BEAM CAP FABRICATOR CONFIGURATION
- SUMMARY

COMPOSITE BEAM CAP FABRICATOR

CONFIGURATION

- COMPOSITE RIBBON FABRICATOR
- COMPOSITE BEAM CAP FABRICATOR
  - DEMONSTRATION MACHINE
  - ALUMINUM BEAM BUILDER INSTALLATION

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT



NOTE

INDUCTION HEATING COILS ARE USED FOR 1ST & 2ND HEATING & FORMING STATIONS

Figure 29

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

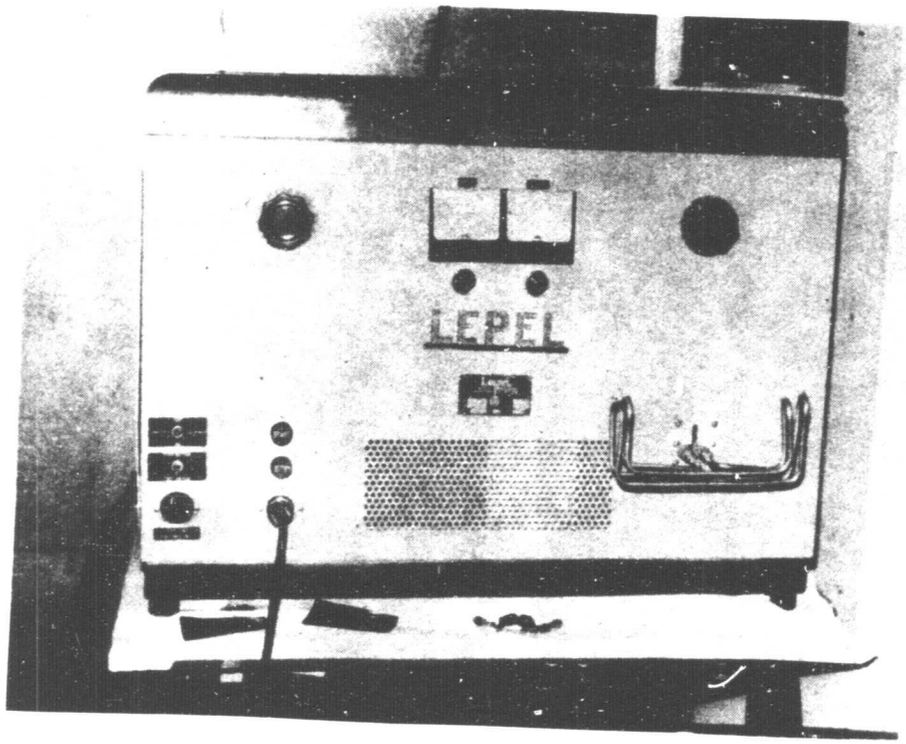


Figure 30

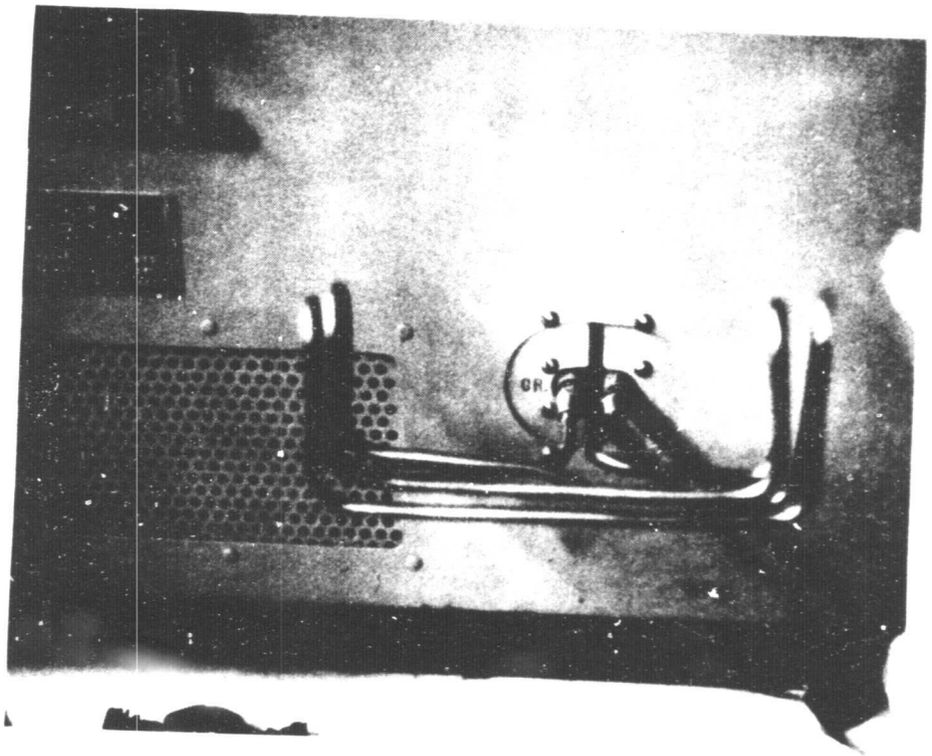


Figure 31

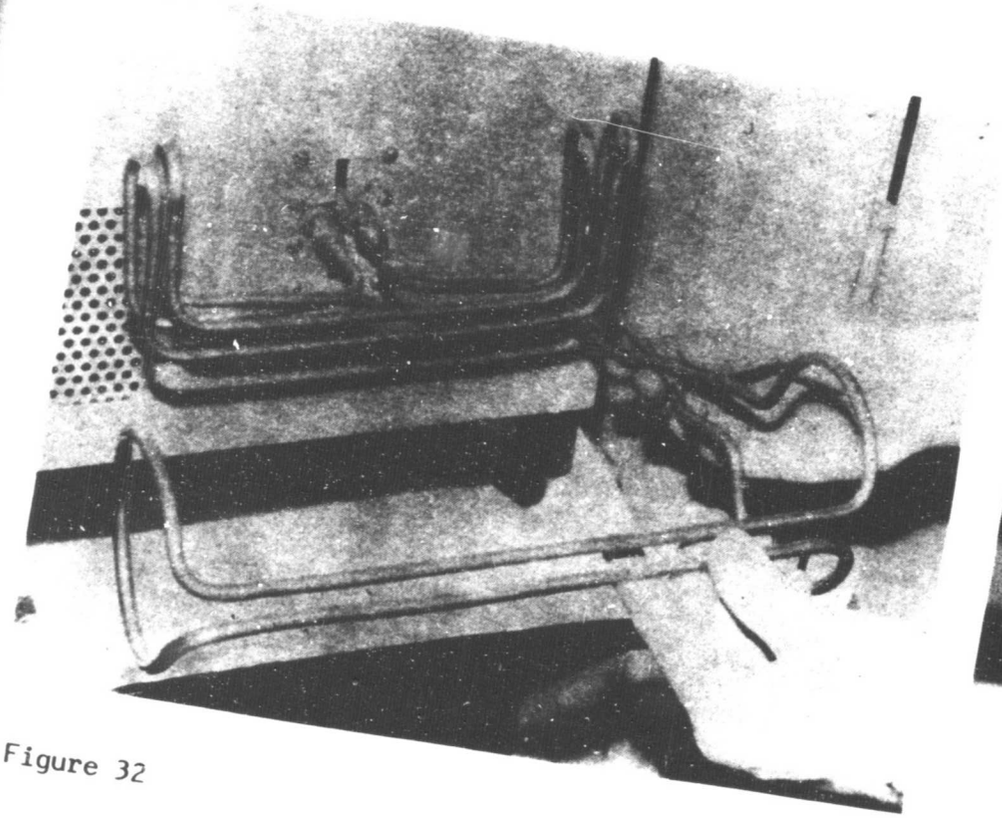


Figure 32

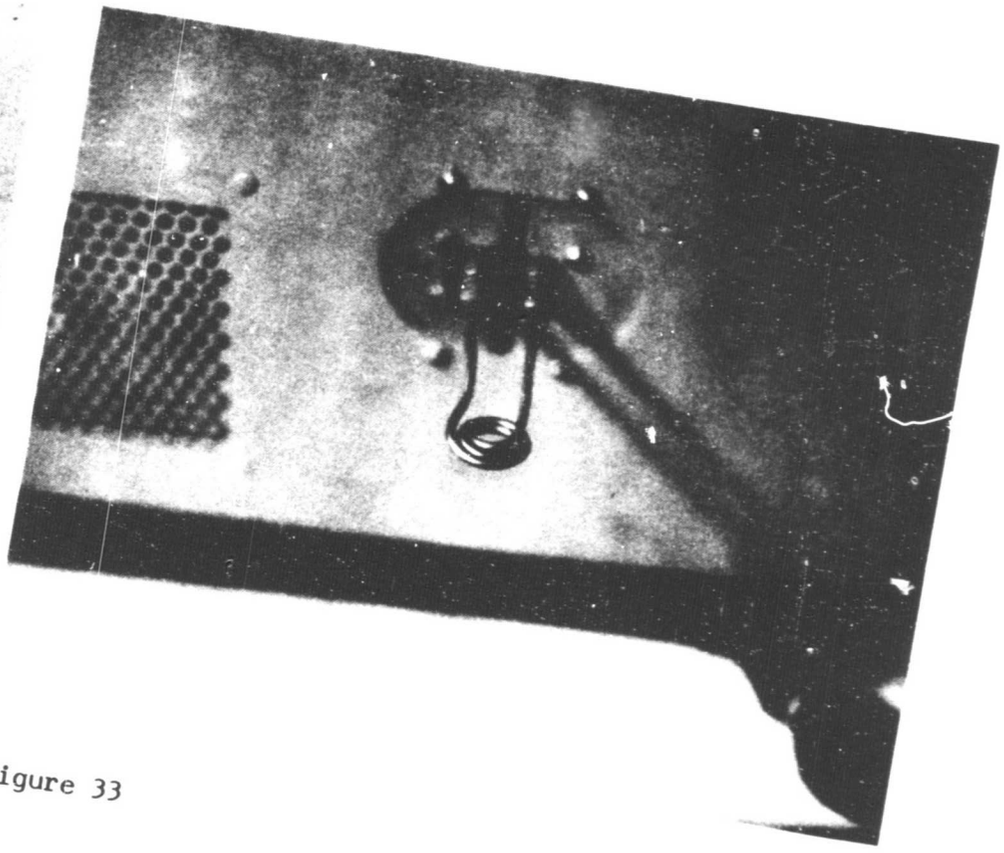


Figure 33

COMPOSITE BEAM CAP
FABRICATOR
DEVELOPMENT

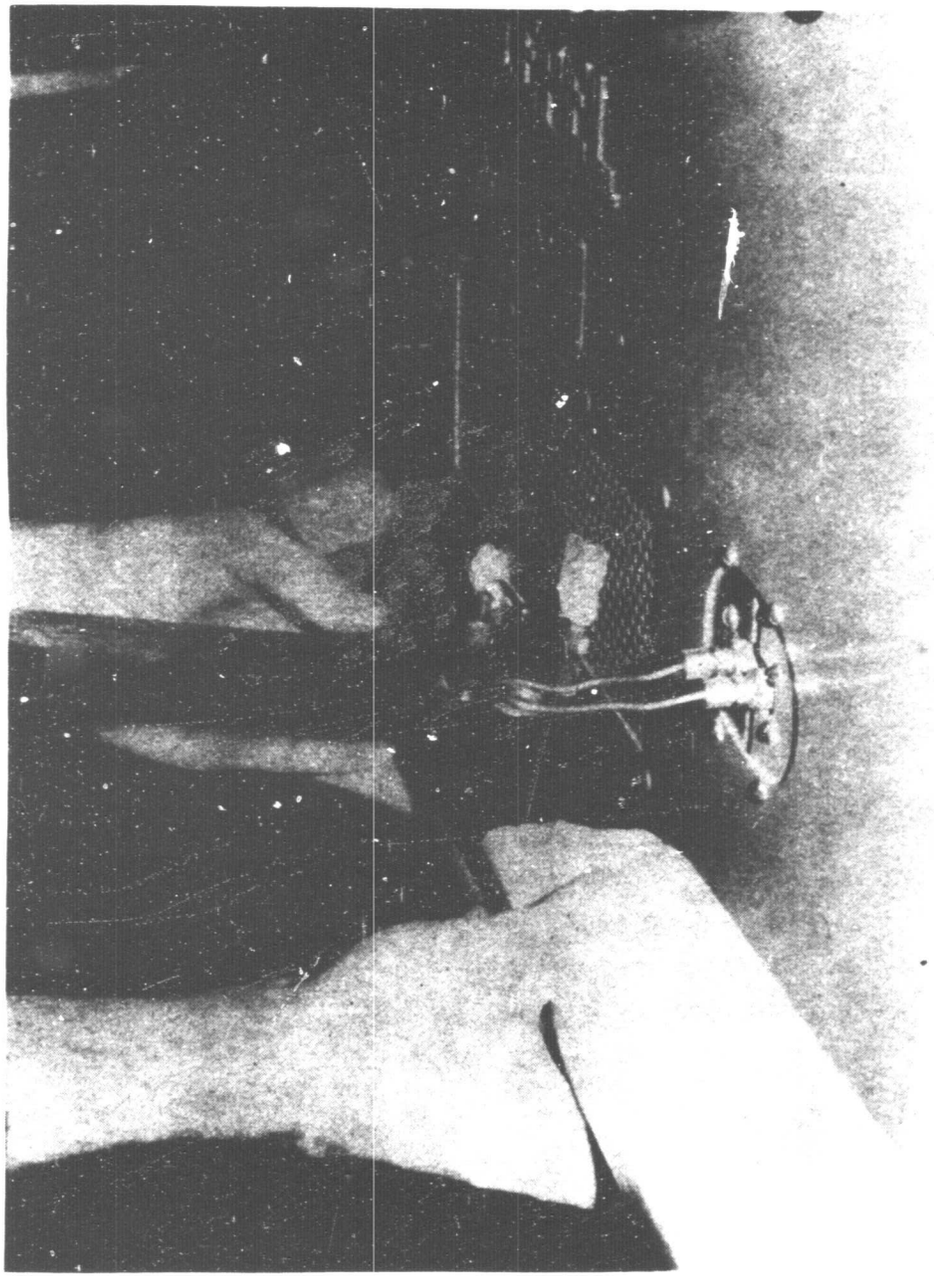


Figure 34

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

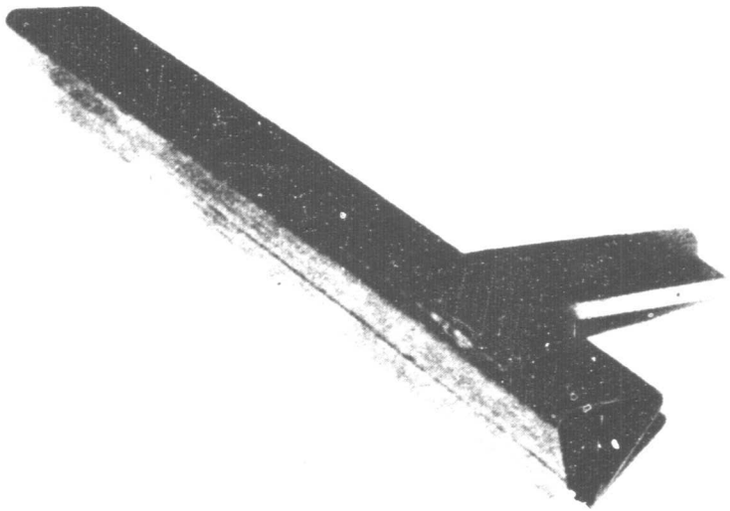


Figure 35

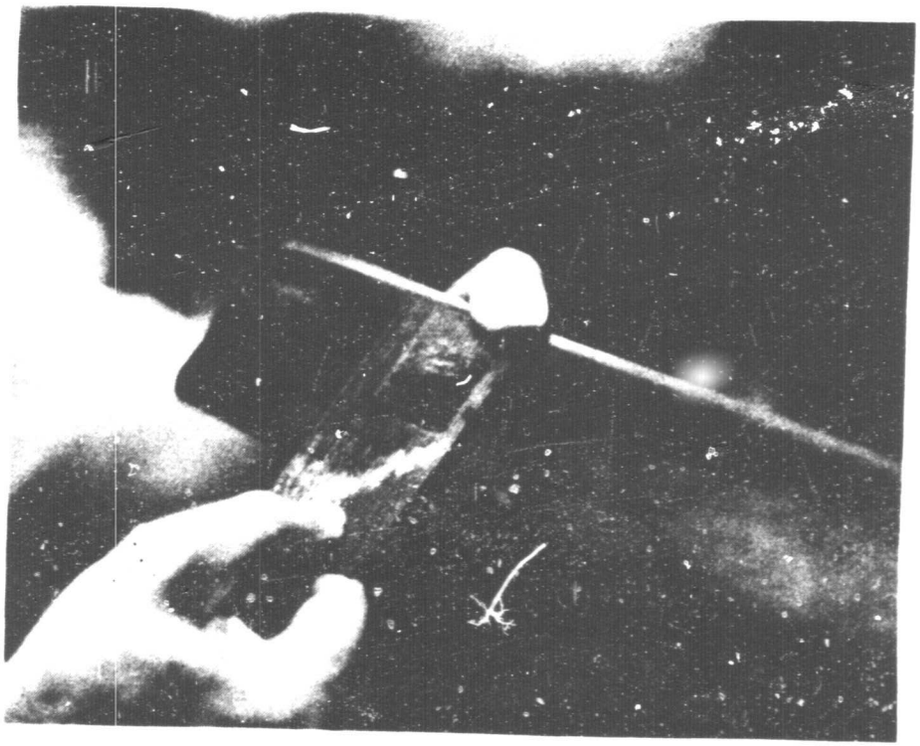


Figure 36

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

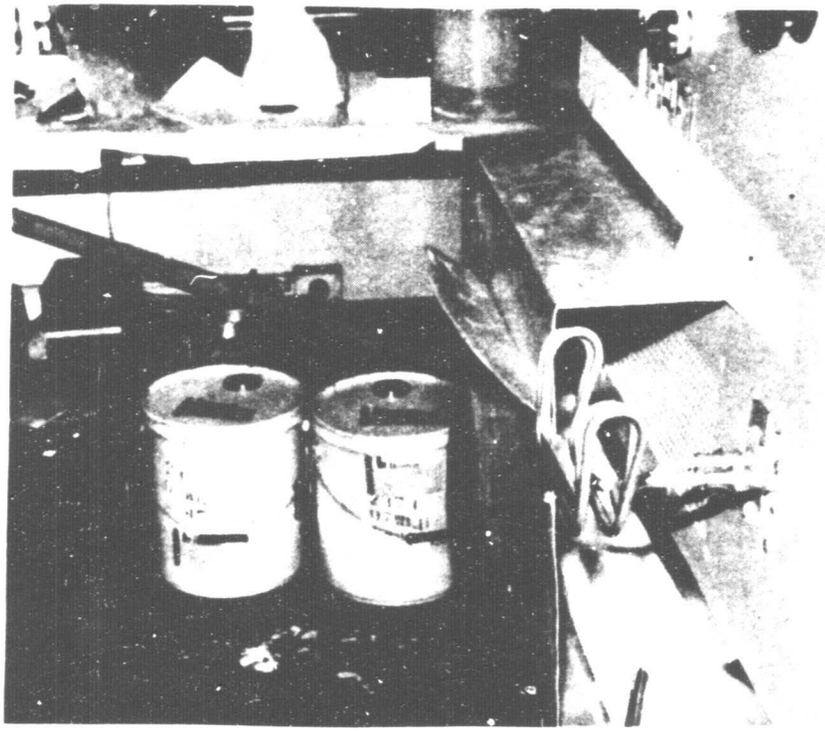


Figure 37

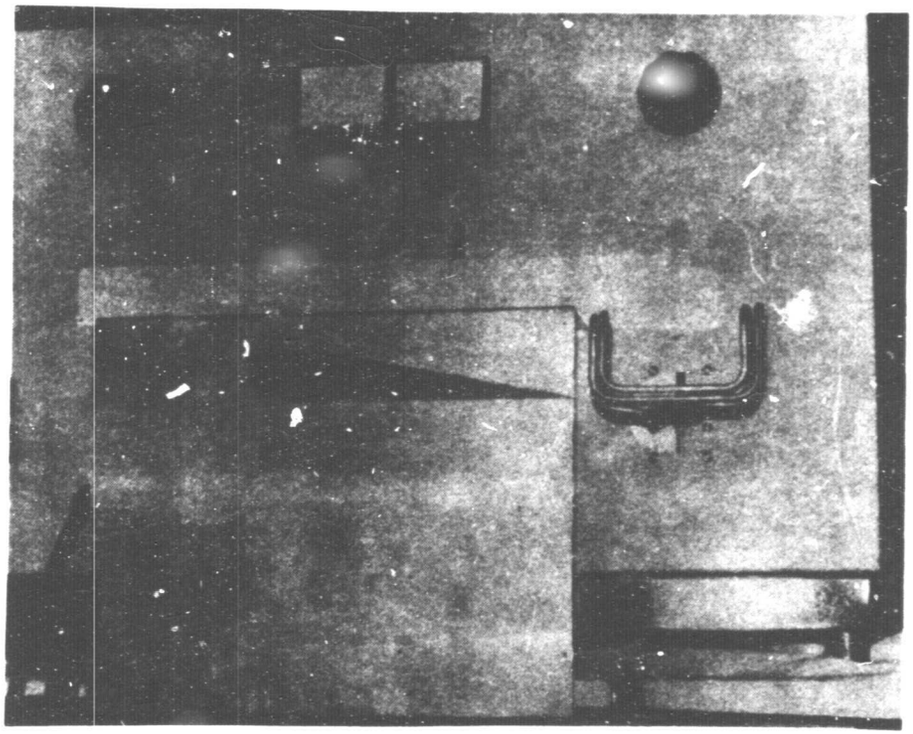


Figure 38

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

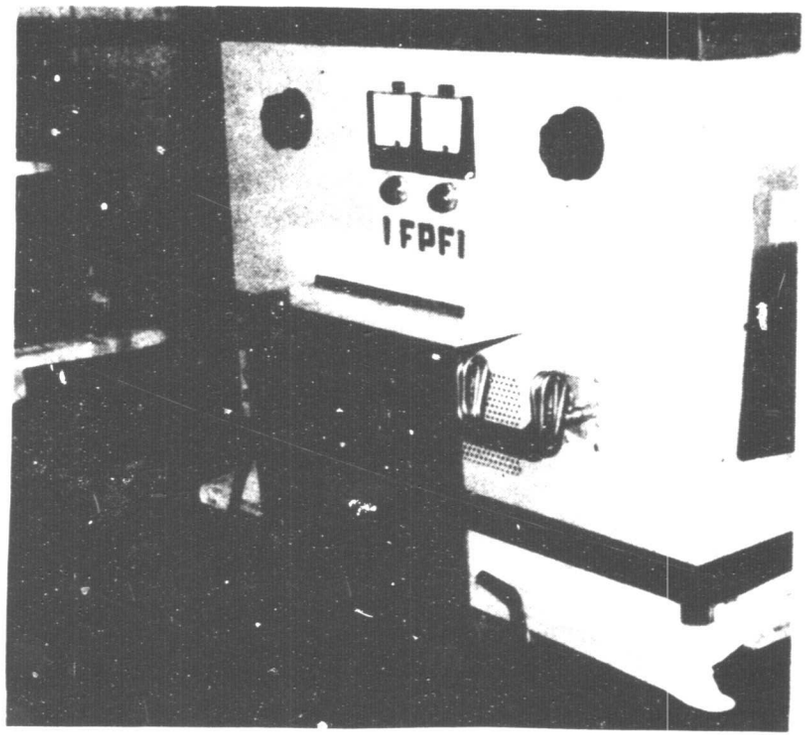


Figure 39

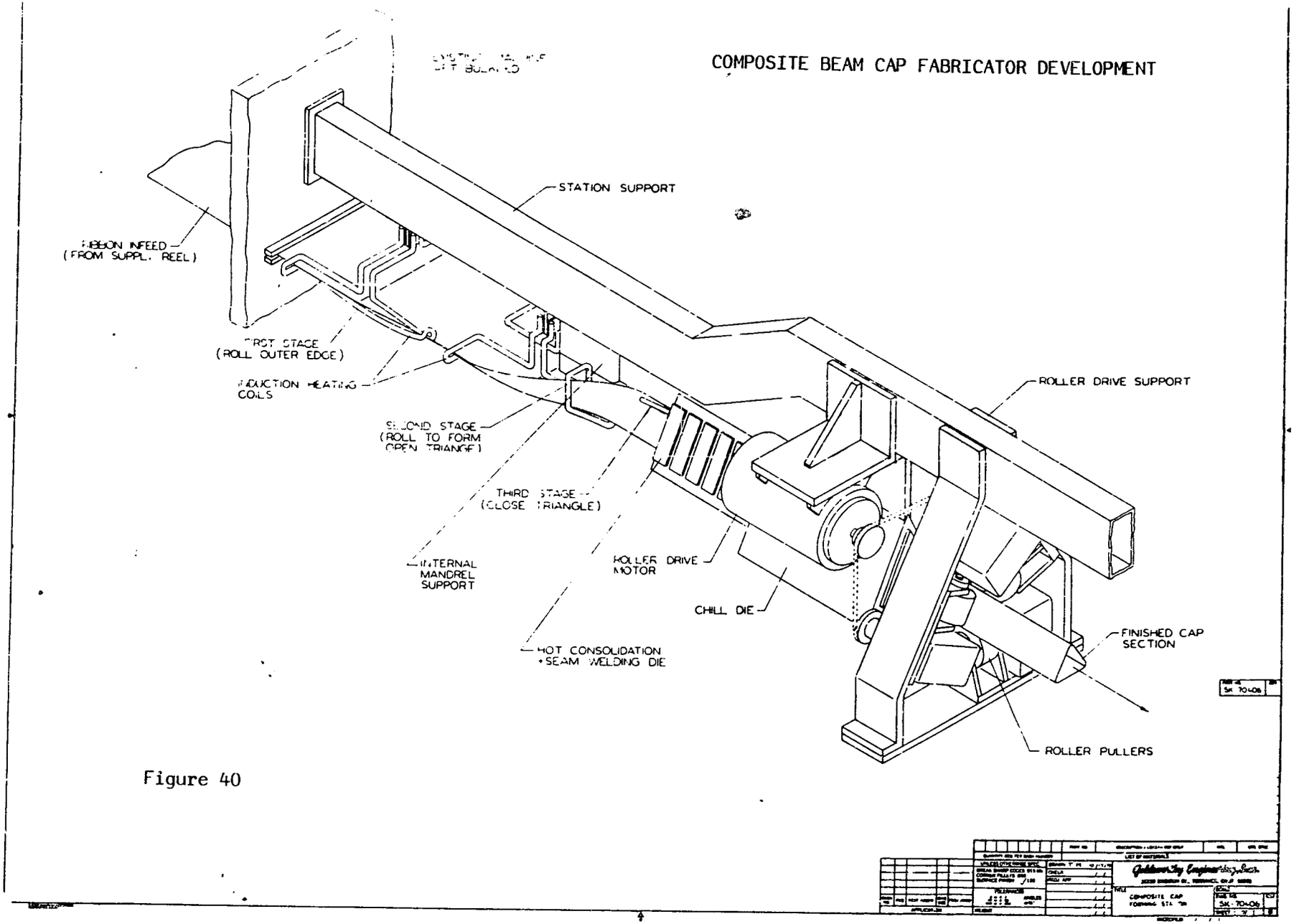

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT
STATION SUPPORT
RIBBON INFEED
(FROM SUPPL. REEL)
FIRST STAGE
(ROLL OUTER EDGE)
INDUCTION HEATING
COILS
SECOND STAGE
(ROLL TO FORM
OPEN TRIANGE)
THIRD STAGE
(CLOSE TRIANGLE)
ROLLER DRIVE SUPPORT
INTERNAL
MANDREL
SUPPORT
ROLLER DRIVE
MOTOR
CHILL DIE
HOT CONSOLIDATION
+SEAM WELDING DIE
FINISHED CAP
SECTION
ROLLER PULLERS

Figure 40

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

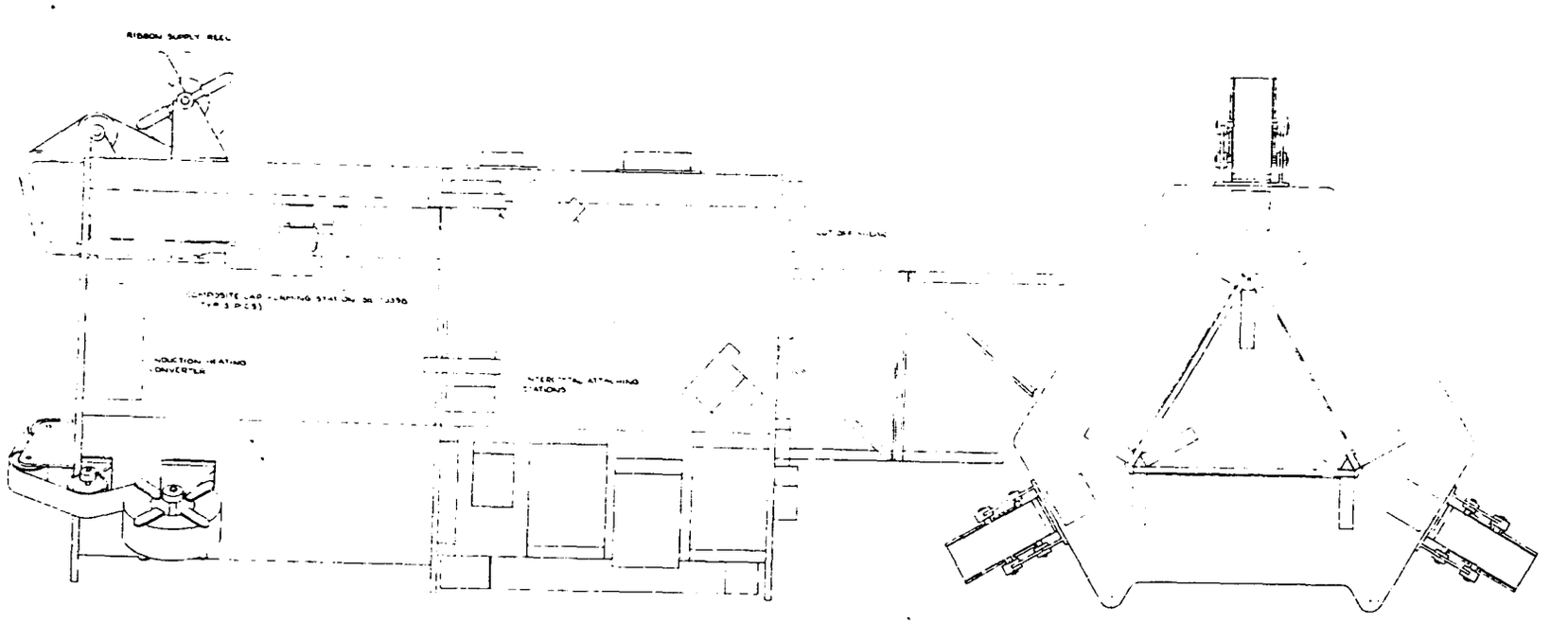


Figure 41

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

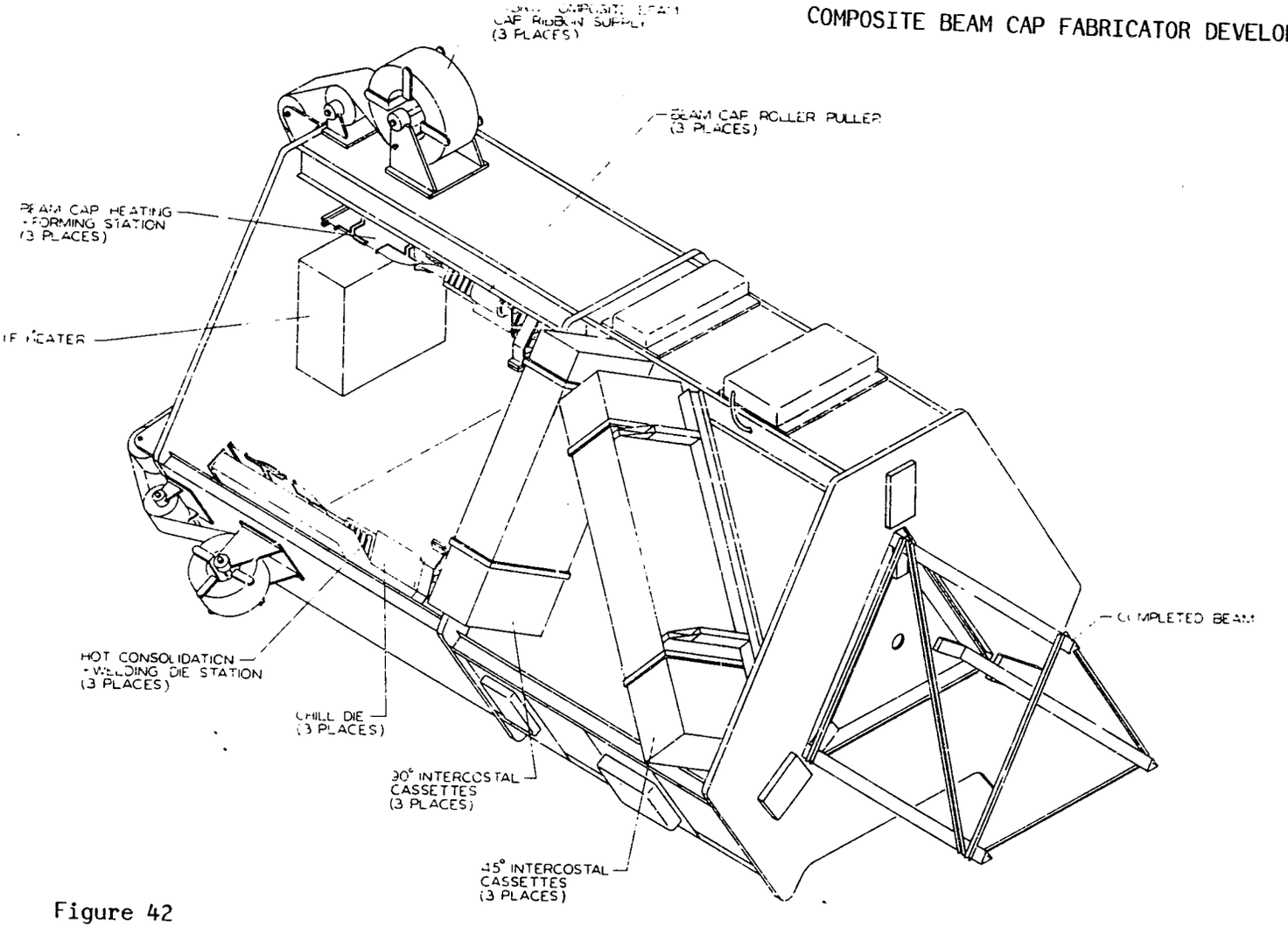


Figure 42

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

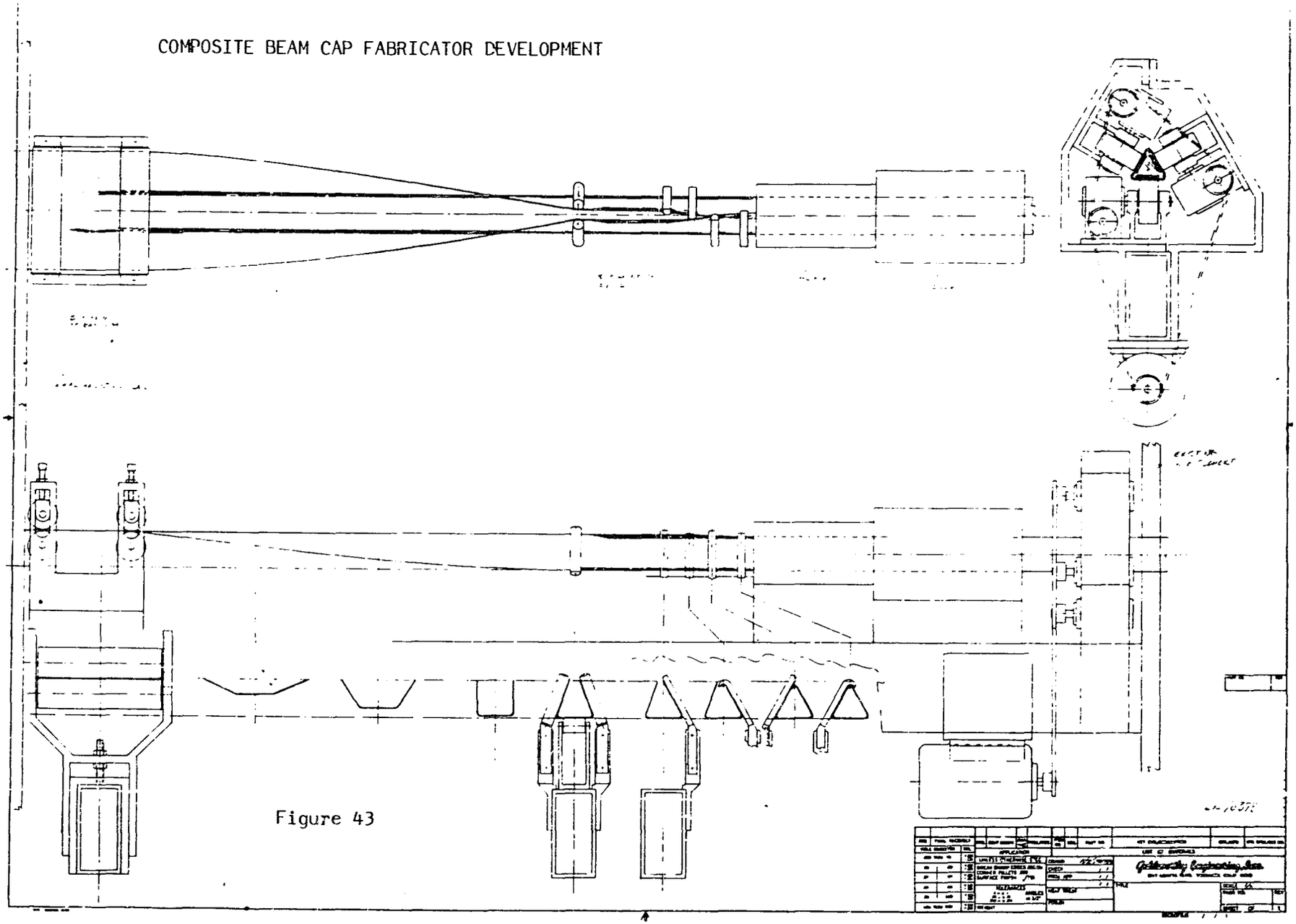
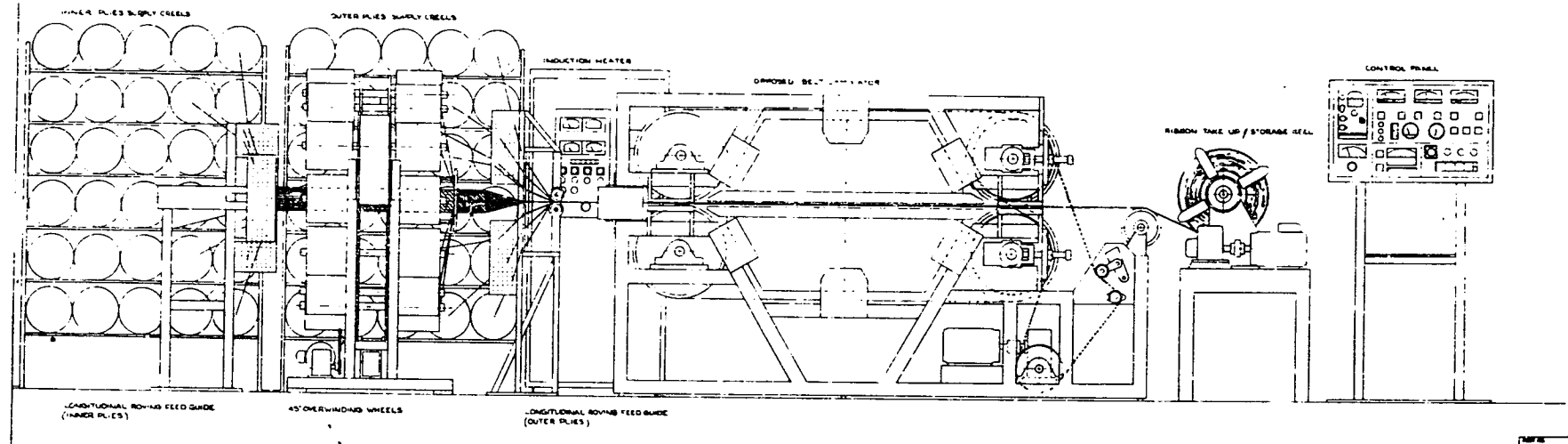


Figure 43

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT



Note
ALL ROVINGS (SUPPLY CREELS / WHEELS) ARE PRE-DRIED

Figure 44

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

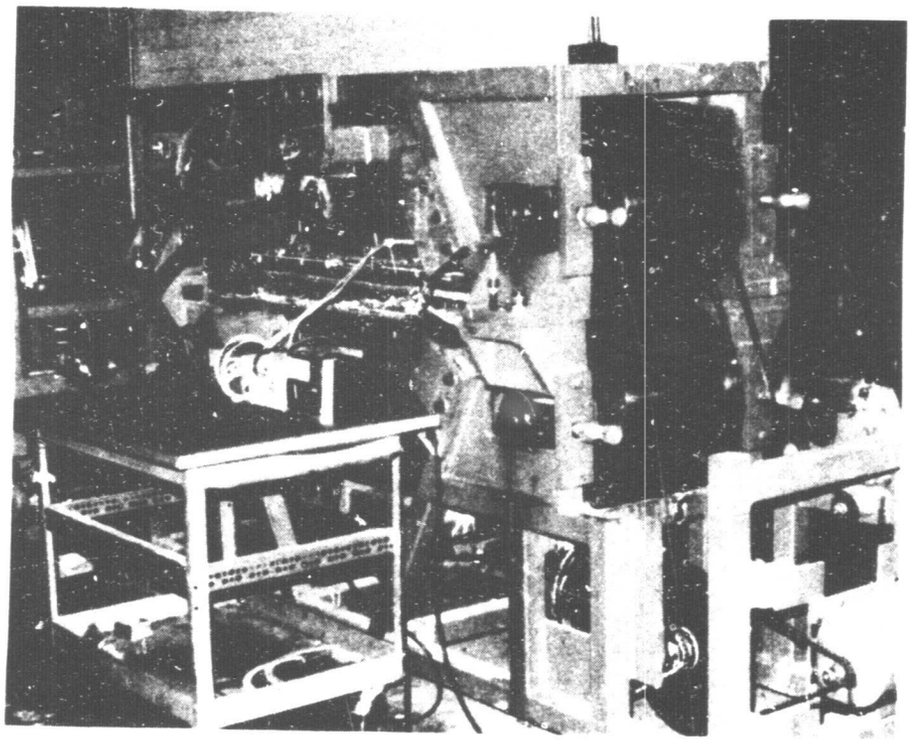


Figure 45

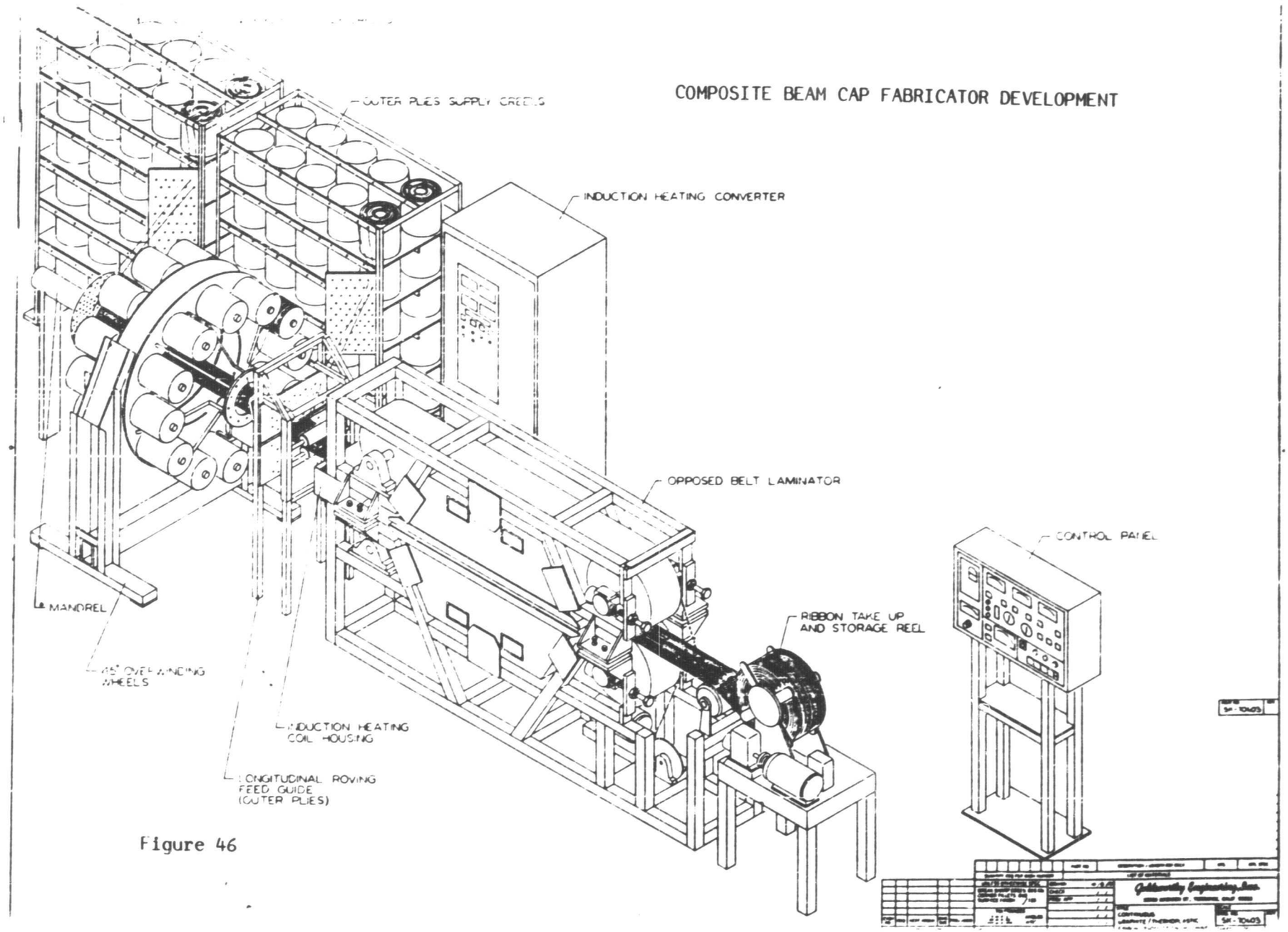

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT
OUTER PLIES SUPPLY CREELS
INDUCTION HEATING CONVERTER
OPPOSED BELT LAMINATOR
CONTROL PANEL
MANDREL
RIBBON TAKE UP AND STORAGE REEL
INDUCTION HEATING COIL HOUSING
LONGITUDINAL ROVING FEED GUIDE (OUTER PLIES)

Figure 46

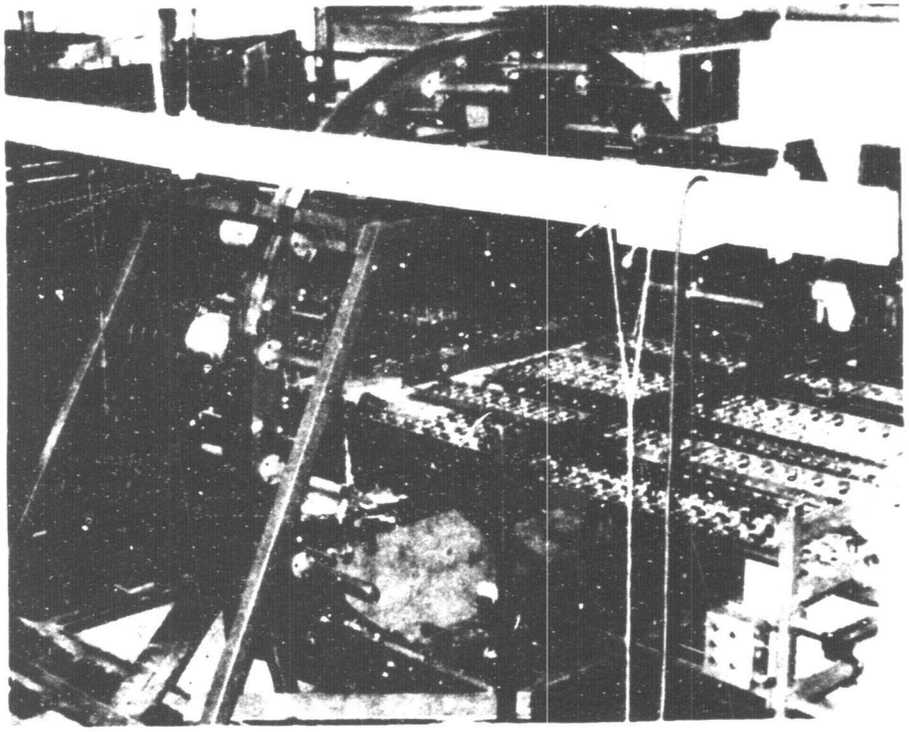


Figure 47

COMPOSITE BEAM CAP FABRICATOR DEVELOPMENT

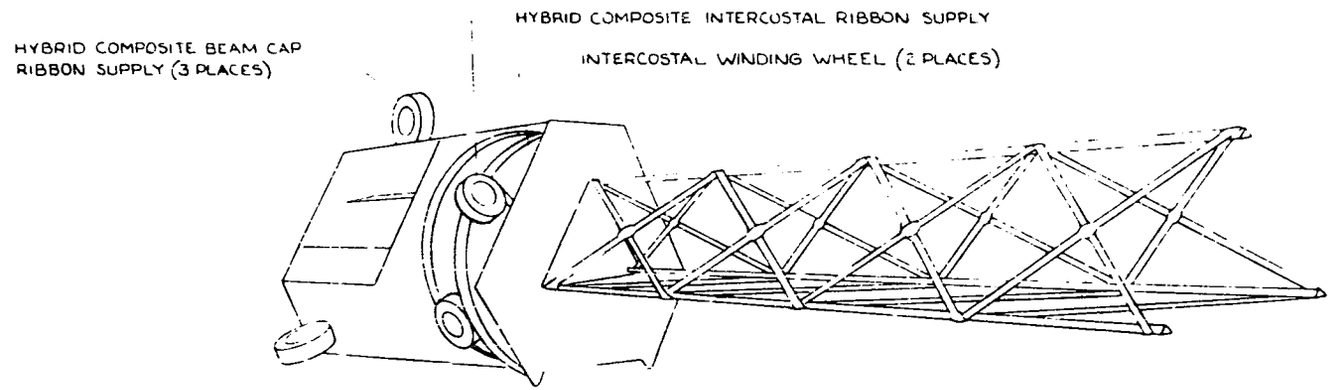


Figure 48

BEAM MACHINE
CONTINUOUS INTERCOSTAL CONCEPT

COMPOSITE BEAM CAP FABRICATOR
NASA-MSFC CONTRACT NAS 8-32472

AGENDA

- OVERVIEW
- PROCESS DEVELOPMENT
- PROCESS EVALUATION
- BEAM CAP FABRICATOR CONFIGURATION
- SUMMARY

SUMMARY

WHAT HAVE WE LEARNED?

- MATERIALS AVAILABILITY
  - PREPREG IS LIMITED
  - CLOTH IS READILY AVAILABLE
  - LAMINATE IS DIFFICULT
- PULTRUSION PROCESS
  - THERMOSET
    - PRESENTS HANDLING DIFFICULTIES
    - 11 FT CAP LENGTH DEMONSTRATED
  - THERMOPLASTIC
    - EASY TO HANDLE
    - 8 FT RIBBON LENGTH DEMONSTRATED
    - 4 FT CAP LENGTH DEMONSTRATED
- [illegible]ED BEAM CAP CHARACTERISTICS
  - [illegible]HIBITS LOW TRANSVERSE STRENGTH AT PRESENT

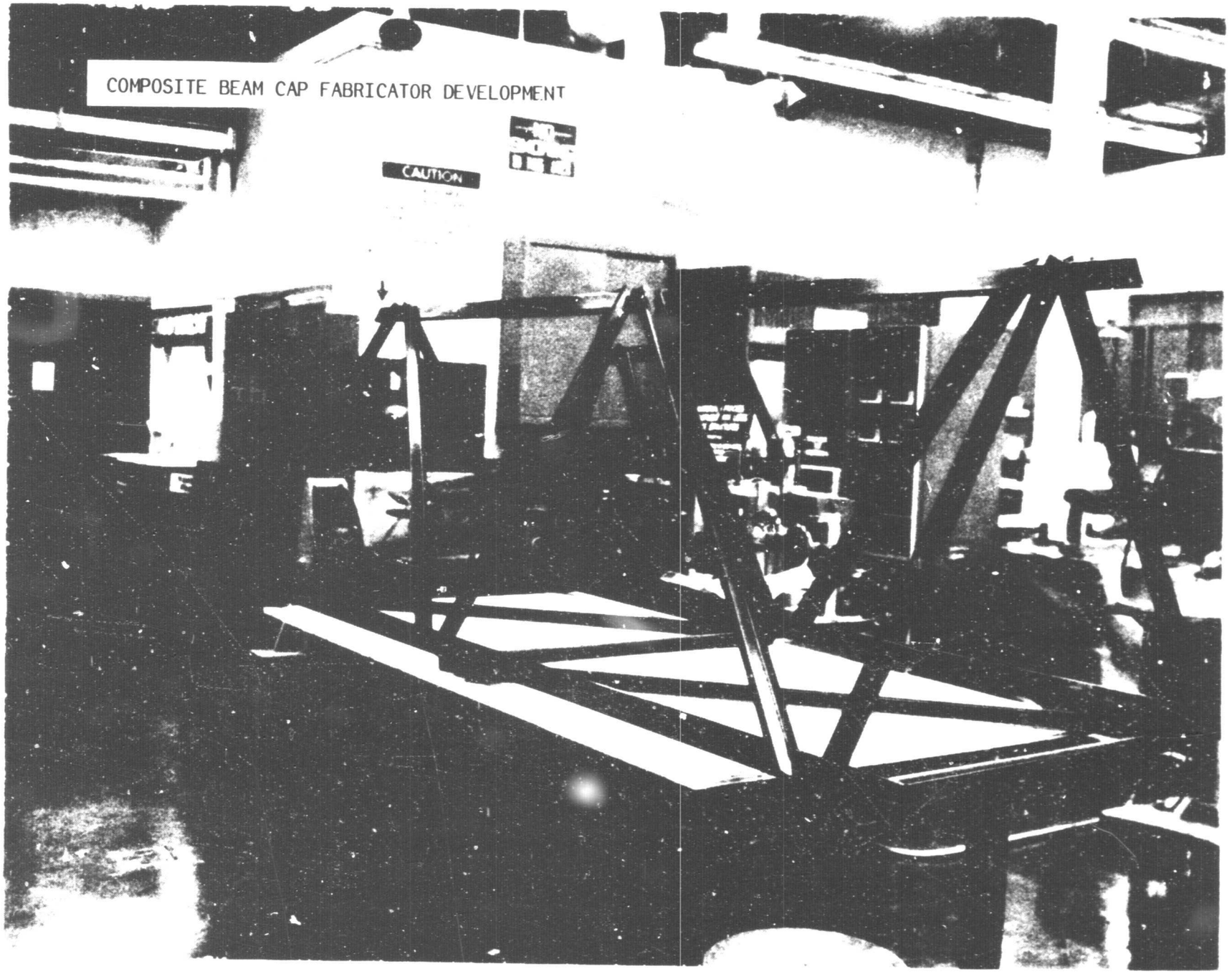


Figure 49